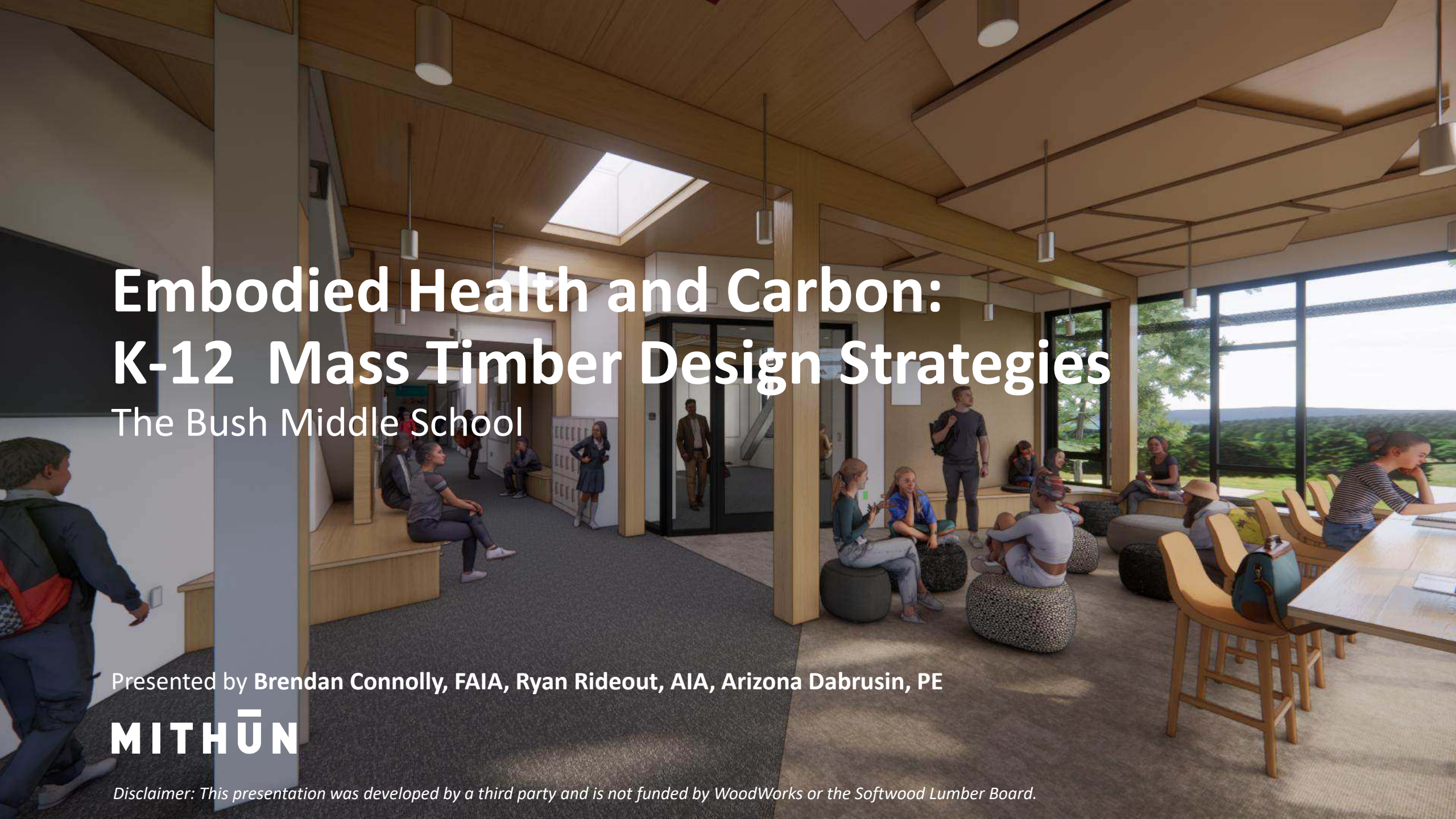

Embodied Health and Carbon: K-12 Mass Timber Design Strategies

The Bush Middle School

Presented by **Brendan Connolly, FAIA, Ryan Rideout, AIA, Arizona Dabrusin, PE**

MITHŪN

Disclaimer: This presentation was developed by a third party and is not funded by WoodWorks or the Softwood Lumber Board.

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AIA Approved Continuing Education

Course Description

This presentation will look at the design of Bush Middle School, a new three-story building in Seattle, WA. The selection of a mass timber structural system was key to meeting project goals related to indoor air quality, biophilic design, and building performance. The presentation will detail key steps in the design process, with project team members sharing how they verify embodied carbon reductions and how collaboration across disciplines helped integrate sustainable design throughout the project.

Learning Objectives

1. Discuss key decisions made during the design process that led to using mass timber to achieve improved indoor air quality, biophilic benefits, and reduced carbon emissions.
2. Understand the design decisions made to prioritize student and faculty wellness, such as connection to the outdoors and exposed wood elements, while ensuring performance and code adherence.
3. Learn about the comparative WBLCA performed on the project, which targeted ILFI Net Zero Carbon and Salmon-Safe certification, and the carbon reductions achieved by using a mass timber structural system.
4. Explore best practices for design team collaboration to meet sustainability goals and end user needs.


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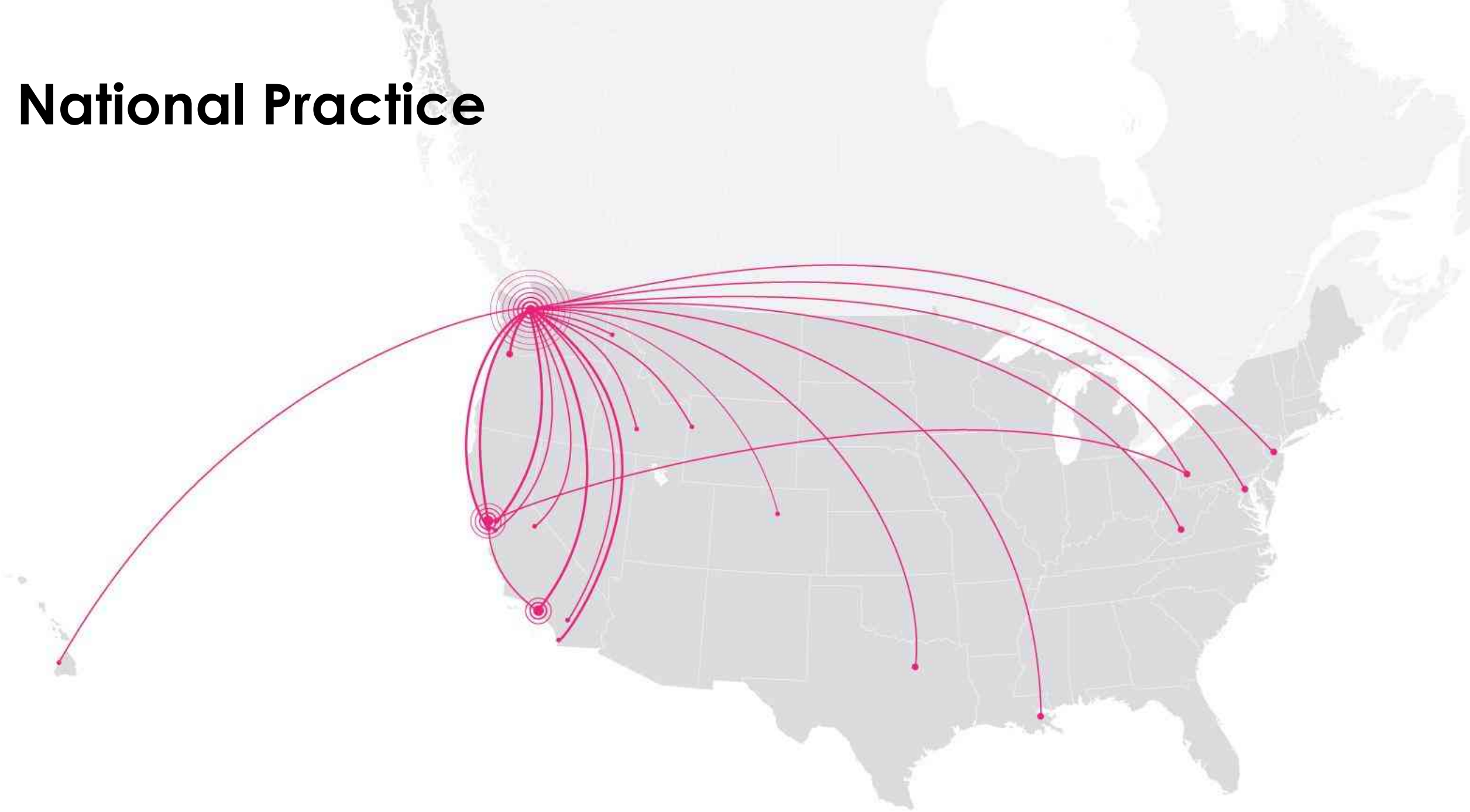
National Practice



8 AIA COTE TOP TEN GREEN AWARDS

10+ NET ZERO ENERGY BUILDINGS

AIA 2030 COMMITMENT

4 Living Building Targeted Buildings

150+ Green Stormwater Projects

15+ PROJECTS WITH GREEN DISTRICT SCALE SYSTEMS

500+ Sustainable Design Presentations

Carbon Neutral Operations Since **2004**

100+ LEED Certified Projects

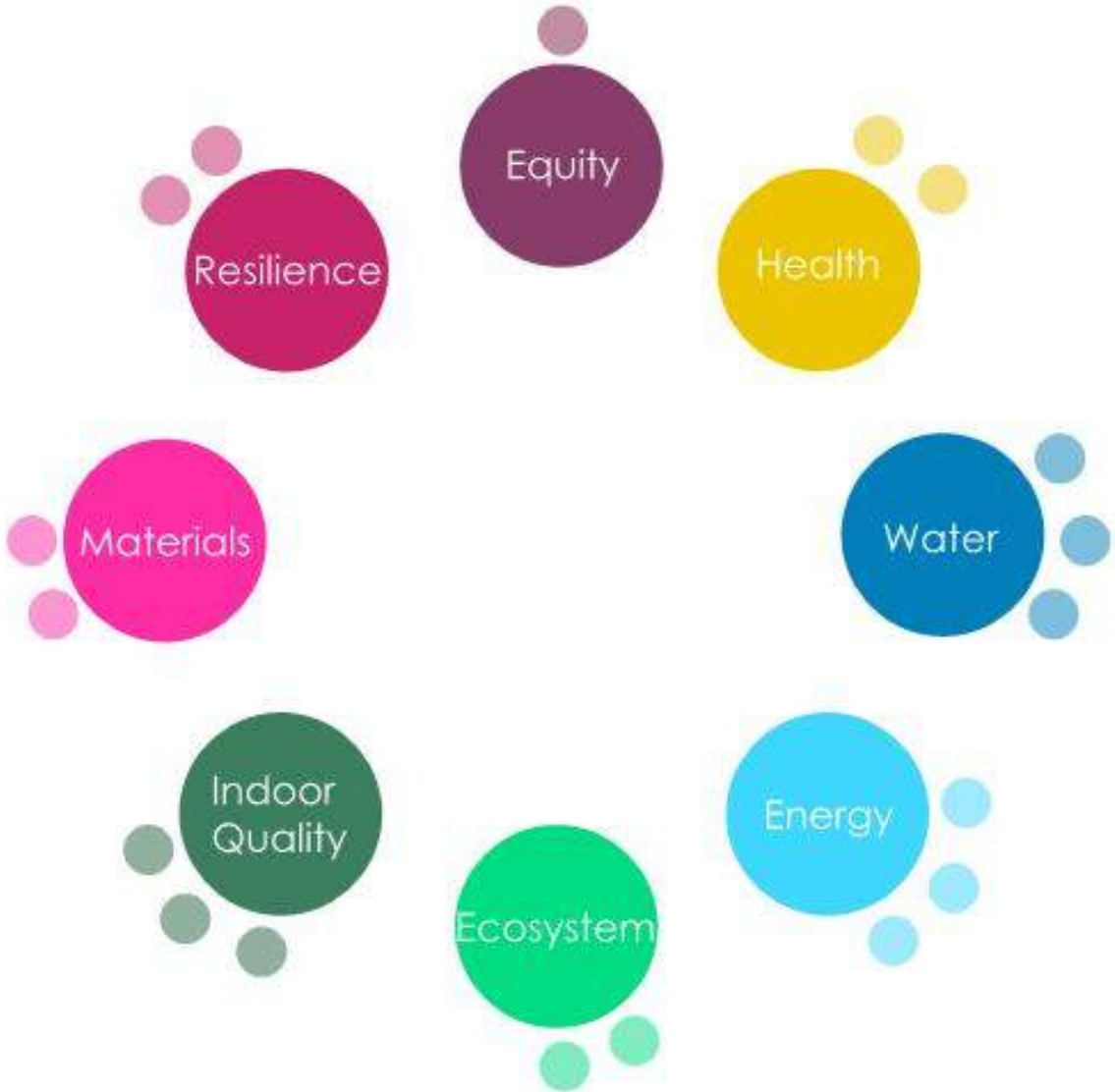
8 District Projects with Healthy Equity Assessments

5 FITWEL + WELL Registered Projects

2 Ecodistricts Registered Projects

large medium small

Mithun Sustainability Framework



Rating Systems

-LEED v4.0

-WASHINGTON SUSTAINABLE SCHOOLS PROTOCOL

-WELL

-LIVING BUILDING CHALLENGE

-PASSIVE HOUSE

-SUSTAINABLE SITES

U.S. GREEN BUILDING COUNCIL USGBC

INTERNATIONAL WELL BUILDING INSTITUTE

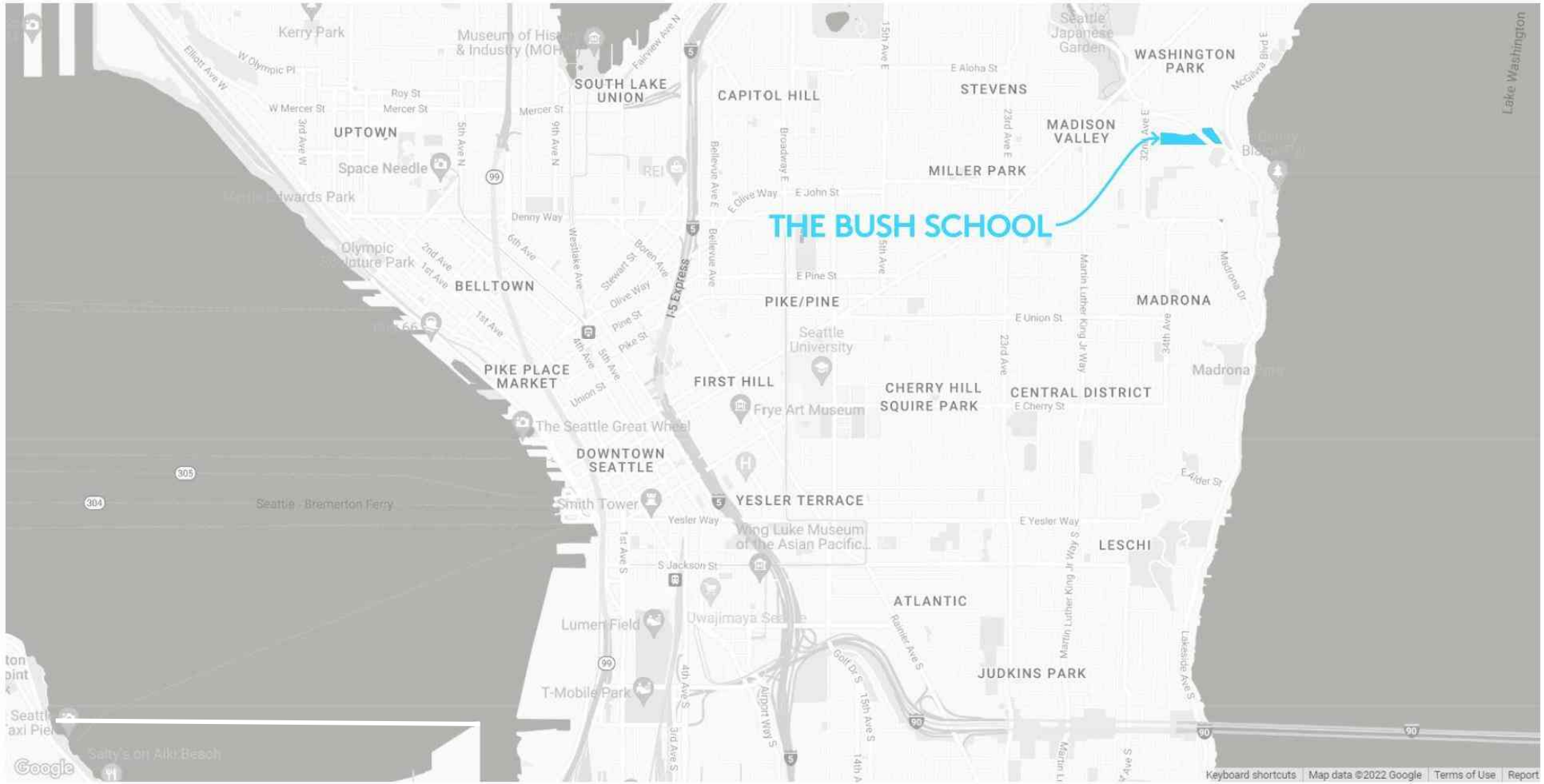
PHIUS Passive House Institute US

The Sustainable SITES Initiative

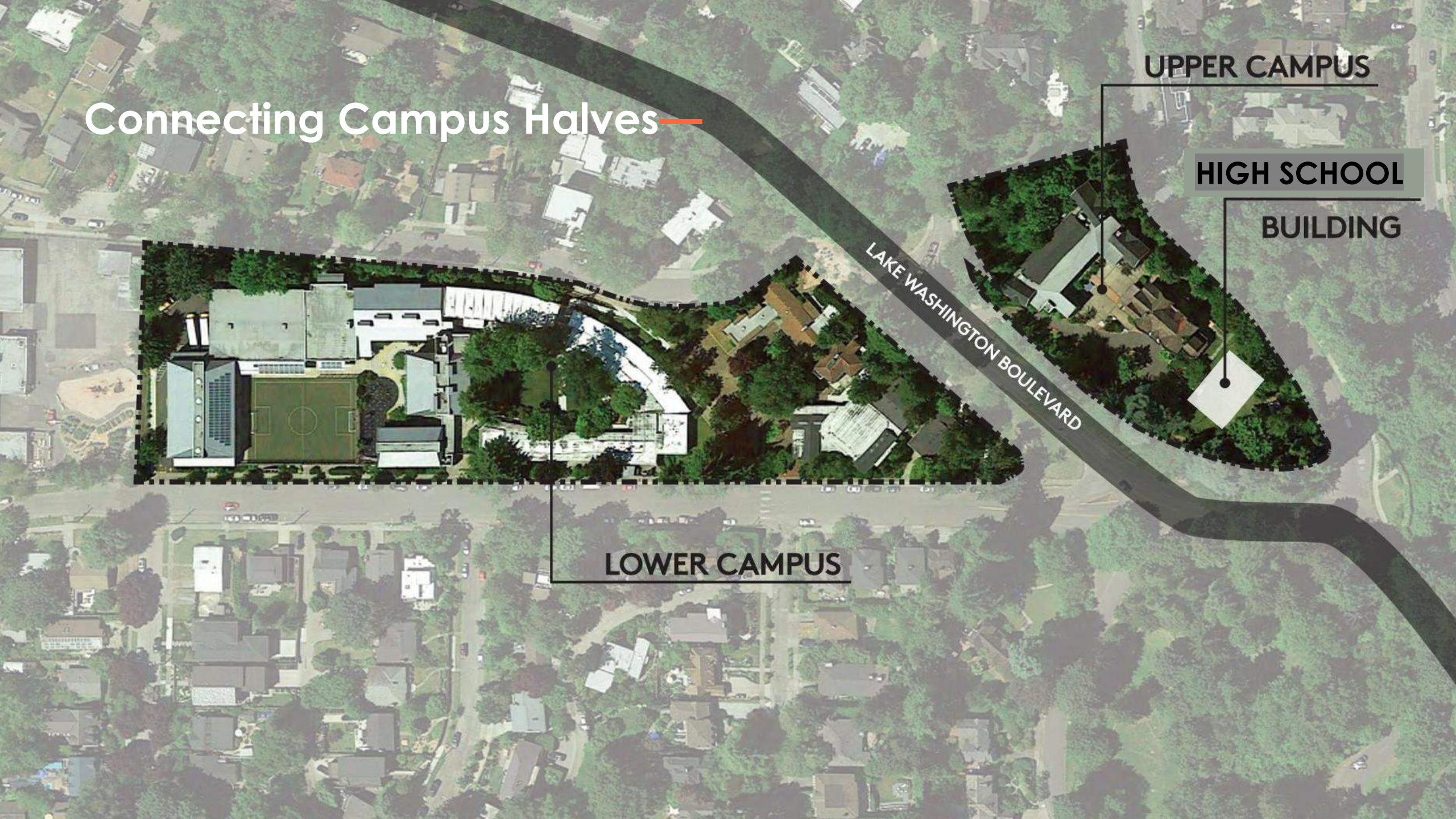
LIVING BUILDING CHALLENGE

The Bush School Vision

A CAMPUS WITHIN THE CITY



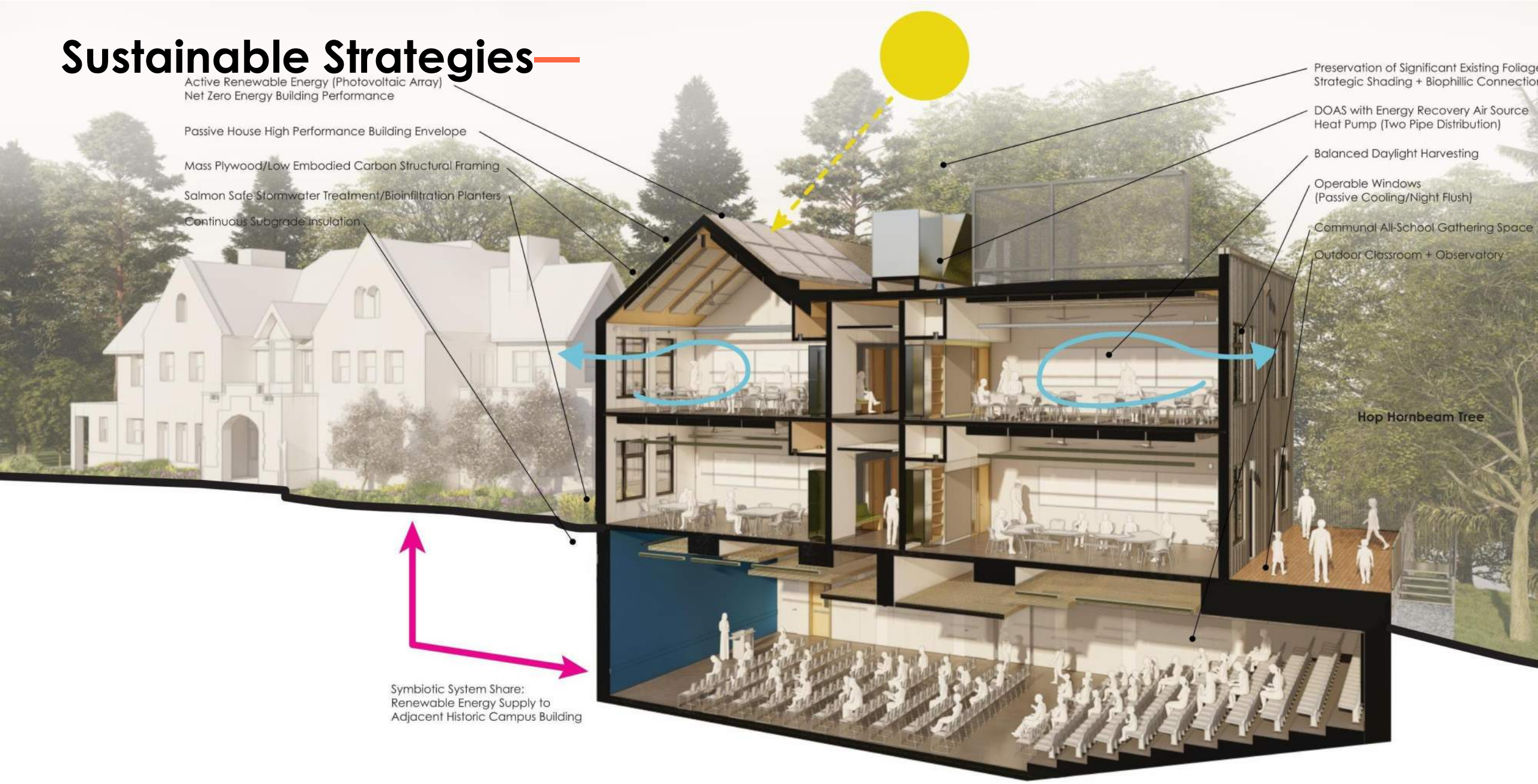
Connecting Campus Halves



The Bush Upper School

The Bush School
Upper School Expansion
Seattle, WA

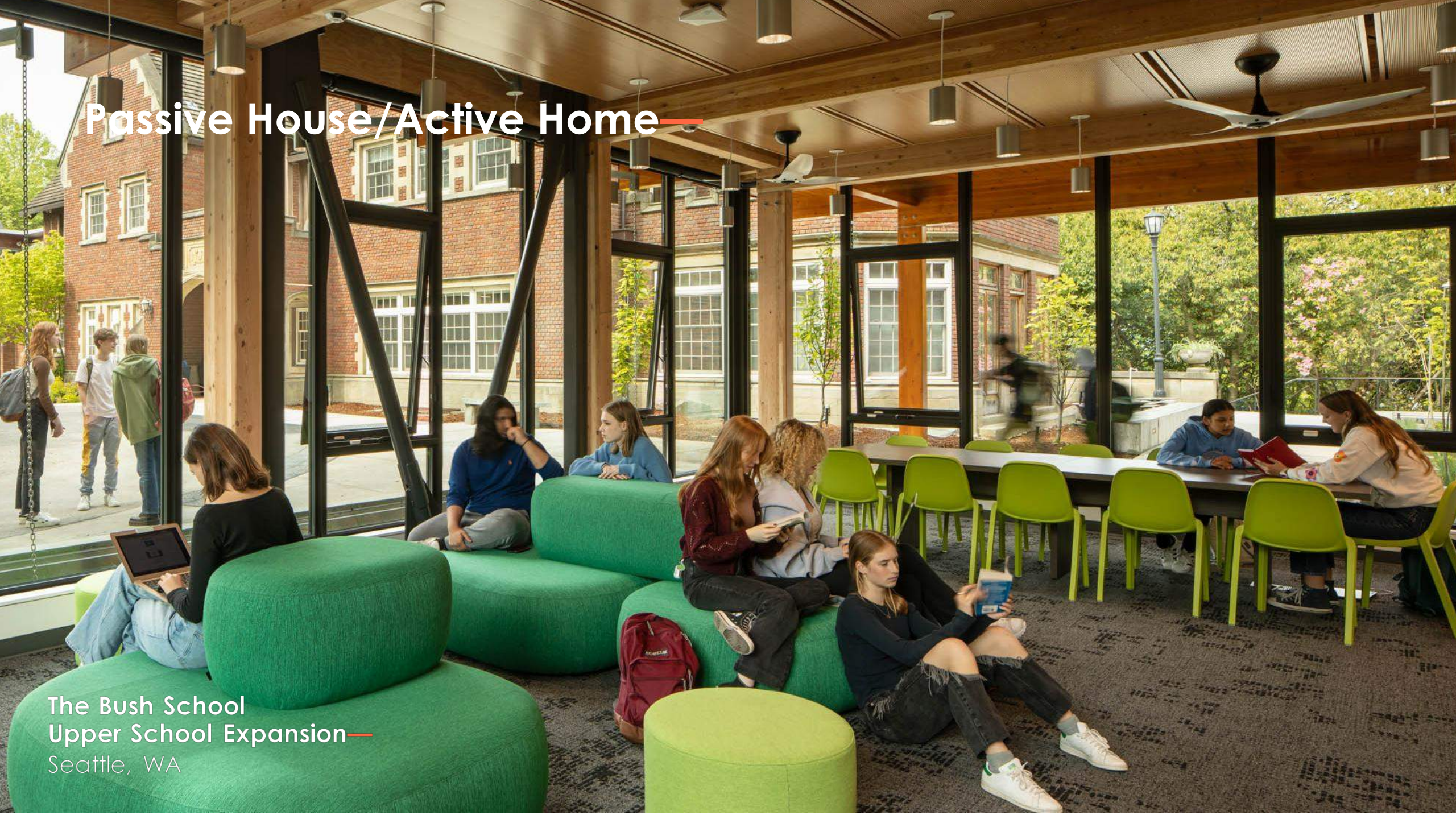
Sustainable Strategies



Creating Visible Change

The Bush School
Mass Timber Upper School Expansion
Seattle, WA

Passive House/Active Home



The Bush School
Upper School Expansion
Seattle, WA

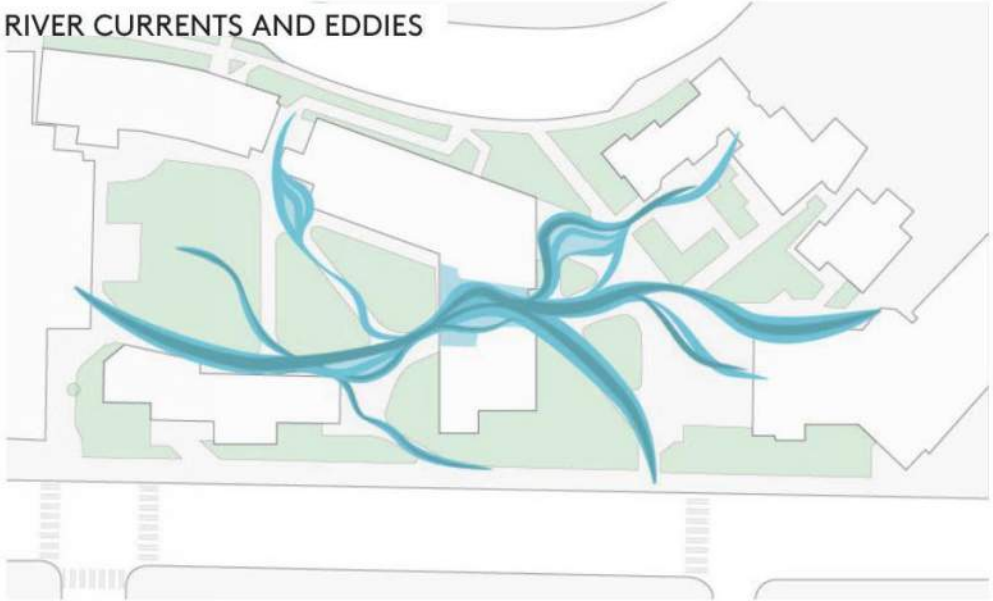
Connection to Nature

The Bush School
Upper School Expansion
Seattle, WA

The Bush Middle School

SITE DIAGRAMS

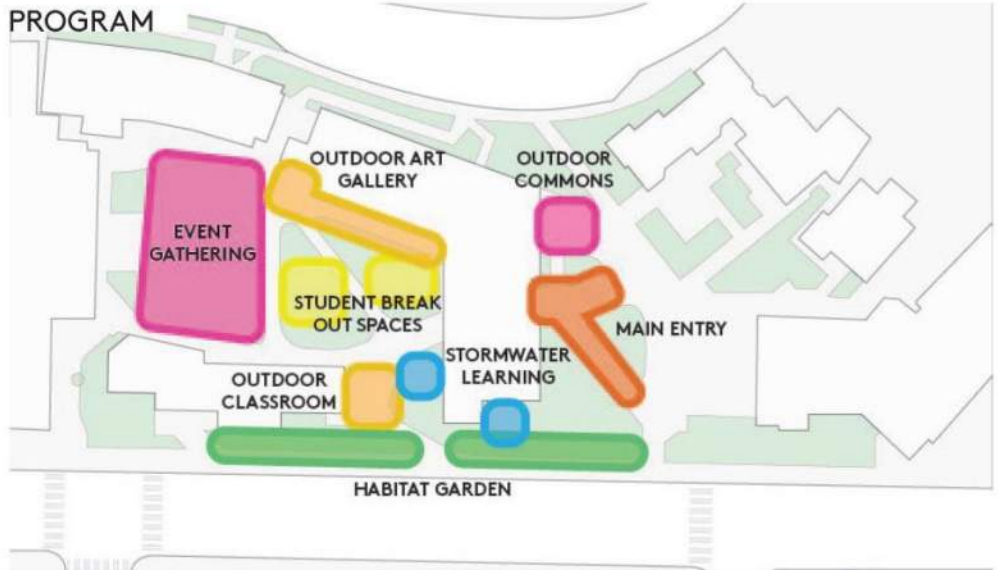
RIVER CURRENTS AND EDDIES



ECOTONES

CIRCULATION

PROGRAM



PRESERVATION OF EXCEPTIONAL TREES

- Unless Considered Hazardous, Exceptional Trees Must Be Protected Per Seattle Municipal Code
- Tree Protection Measures Will Be Required For The Big Tree Adjacent To The Construction Site
- Opportunity To Improve The Rooting Environment Around Redwood Tree At Harrision

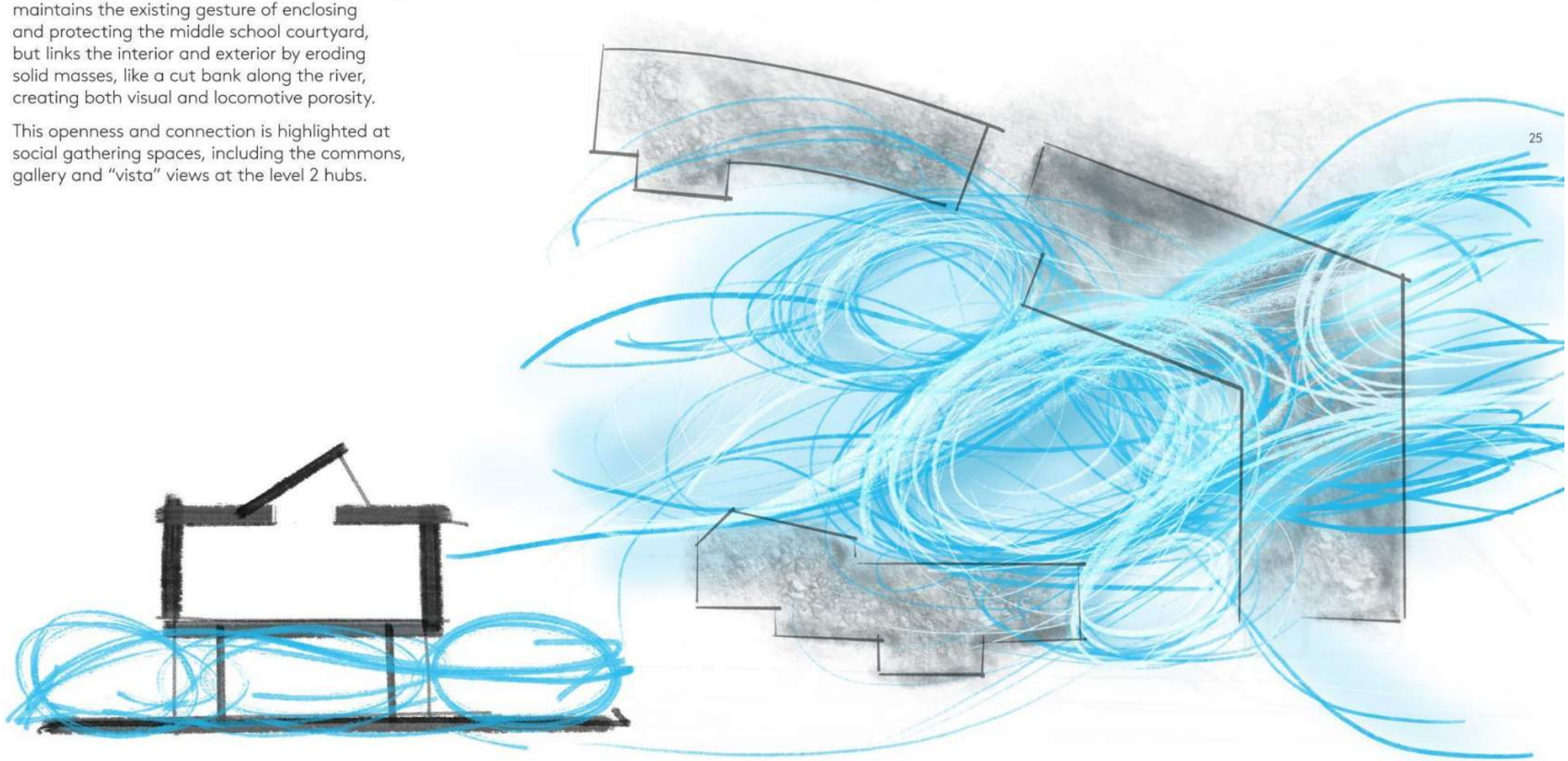
Courtyard Level

Classroom Level

DESIGN CONCEPTS

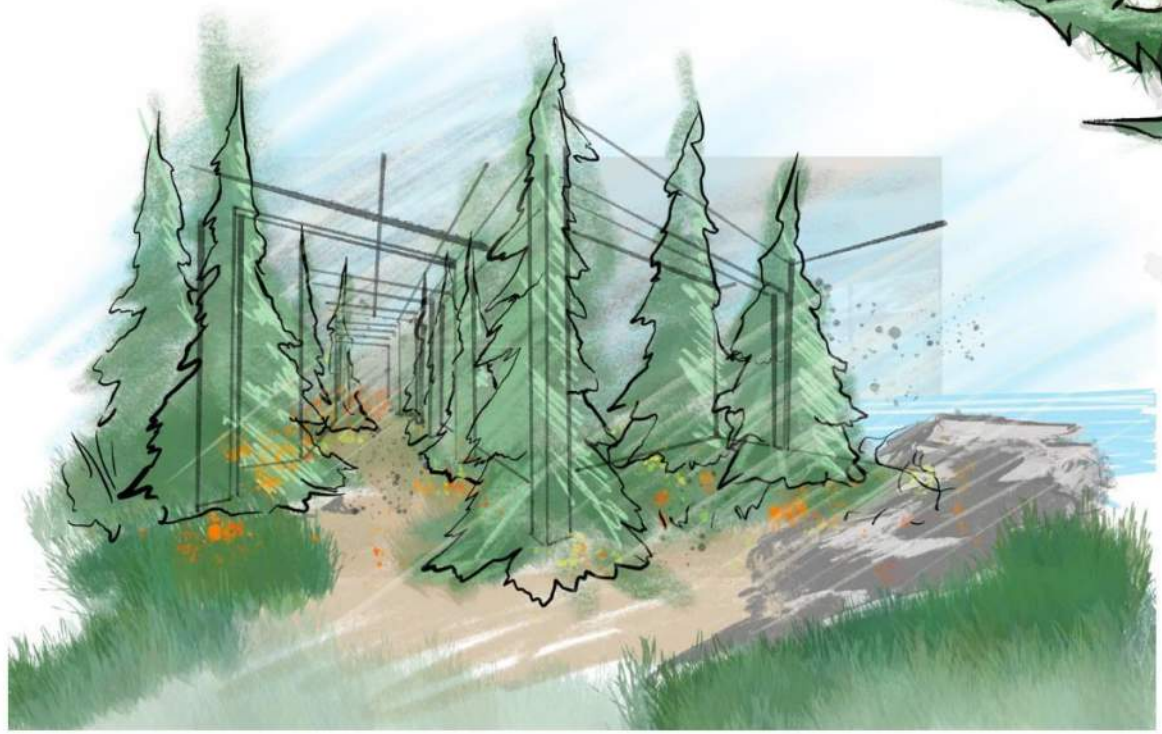
The journey from K-12 is a river. The new building maintains the existing gesture of enclosing and protecting the middle school courtyard, but links the interior and exterior by eroding solid masses, like a cut bank along the river, creating both visual and locomotive porosity.

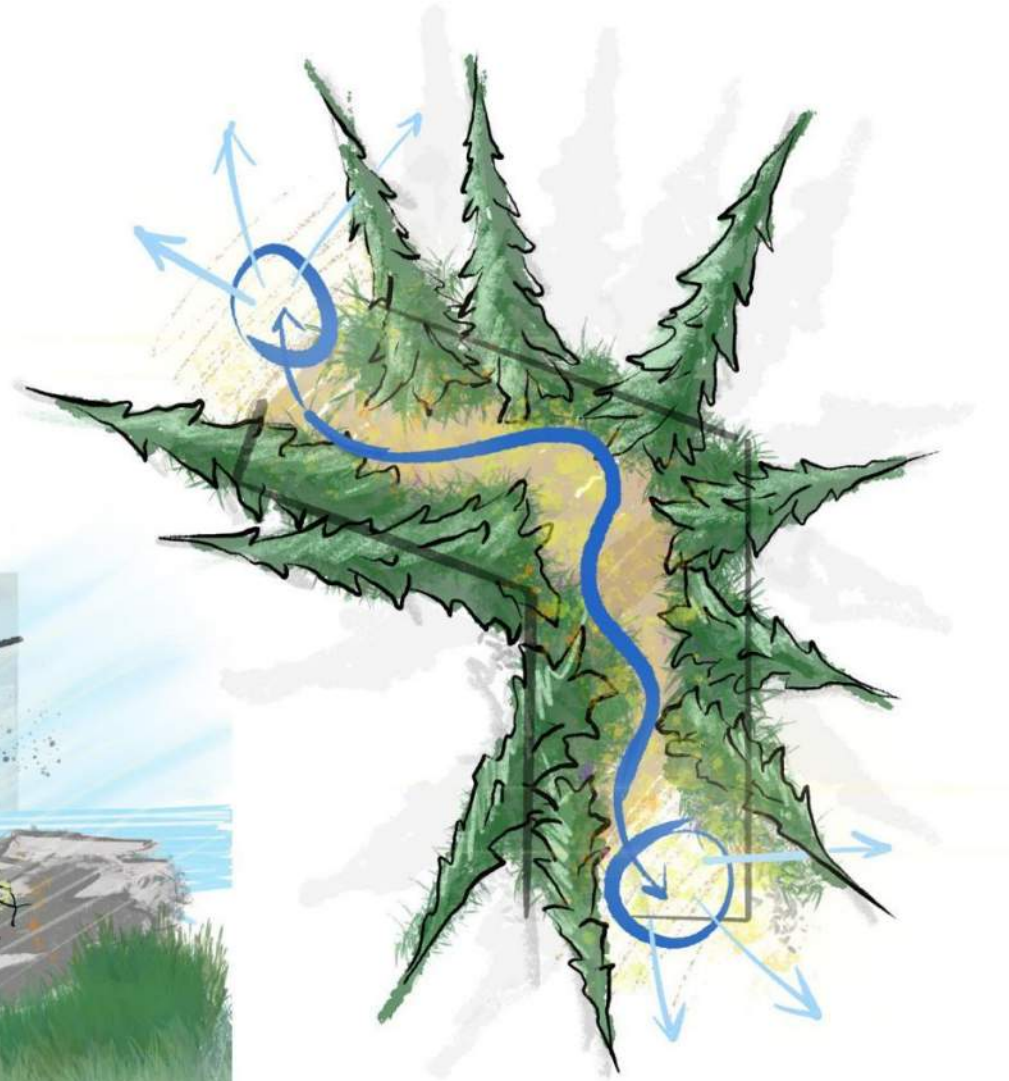
This openness and connection is highlighted at social gathering spaces, including the commons, gallery and "vista" views at the level 2 hubs.



DESIGN CONCEPTS

At level 2 of the new building, the place of learning and growth, the heavy timber structure becomes a forest of dappled light through the tree canopy, where trees give way to clearings at open vistas and meadows. The journey through the forest inspires curiosity, invites exploration, while providing refuge, respite, and outlook.





Mass Timber R&D

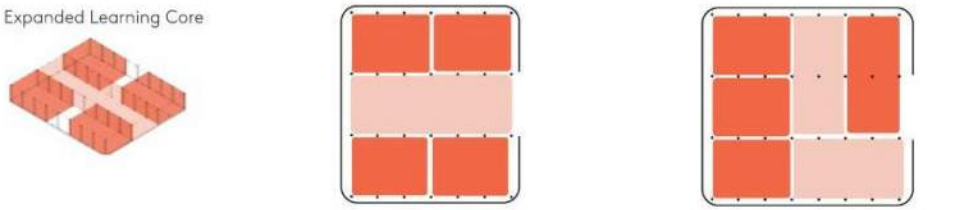
Building Better Schools

Research & Development

Kit of Parts - Adaptability

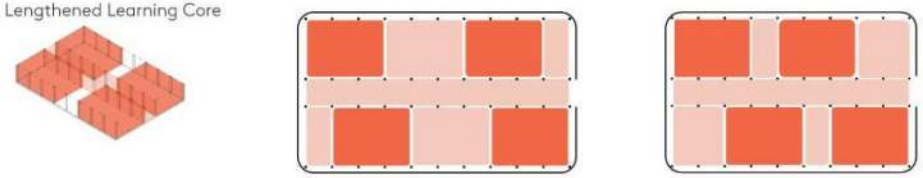
4-UP Program

Expanded Learning Core



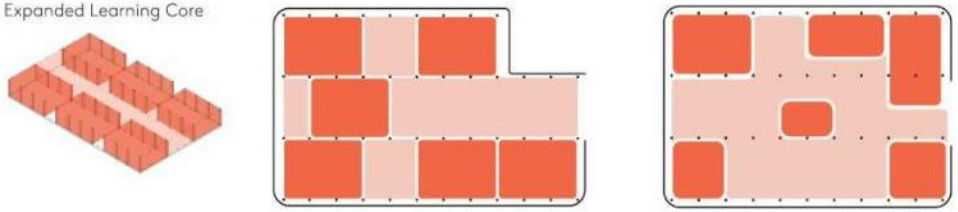
4-UP Program

Lengthened Learning Core



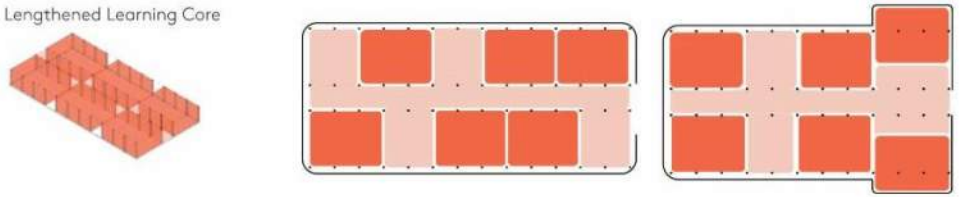
6-UP Program

Expanded Learning Core



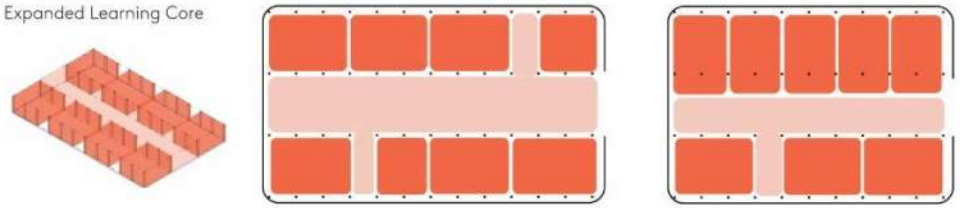
6-UP Program

Lengthened Learning Core



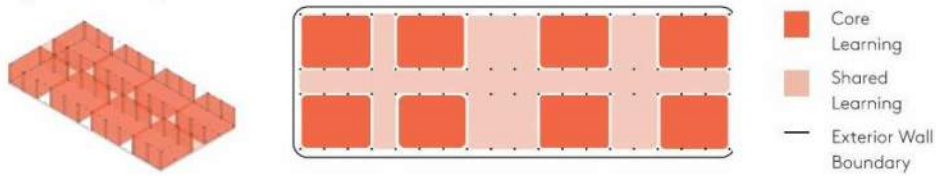
8-UP Program

Expanded Learning Core



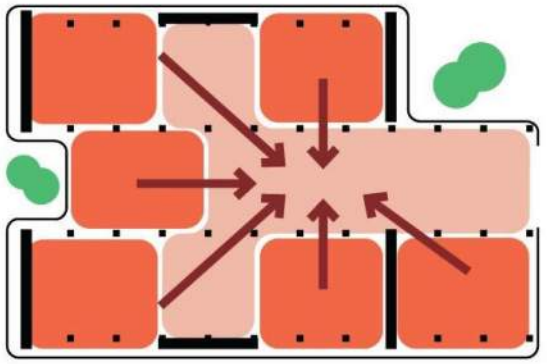
8-UP Program

Lengthened Learning Core

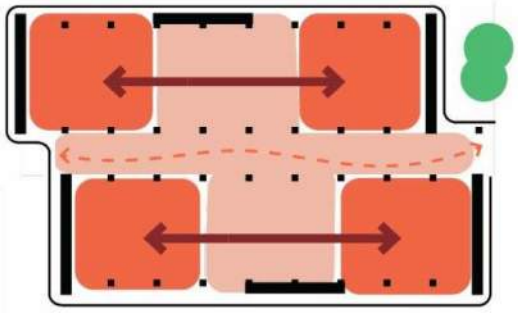


Modeling Learning Environment Agility Model Concepts

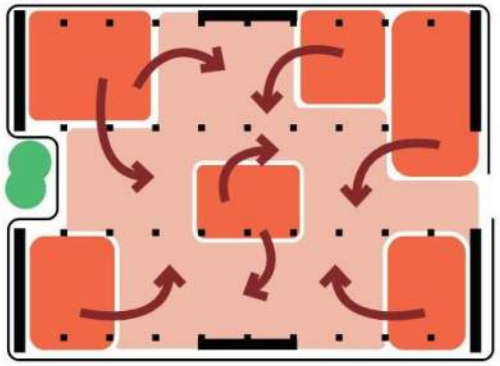
Central Learning Hub



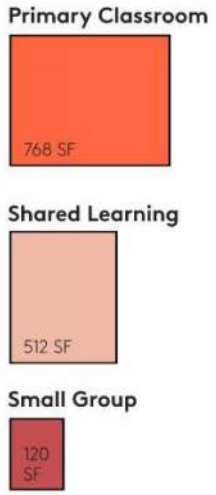
Paired Learning Partners

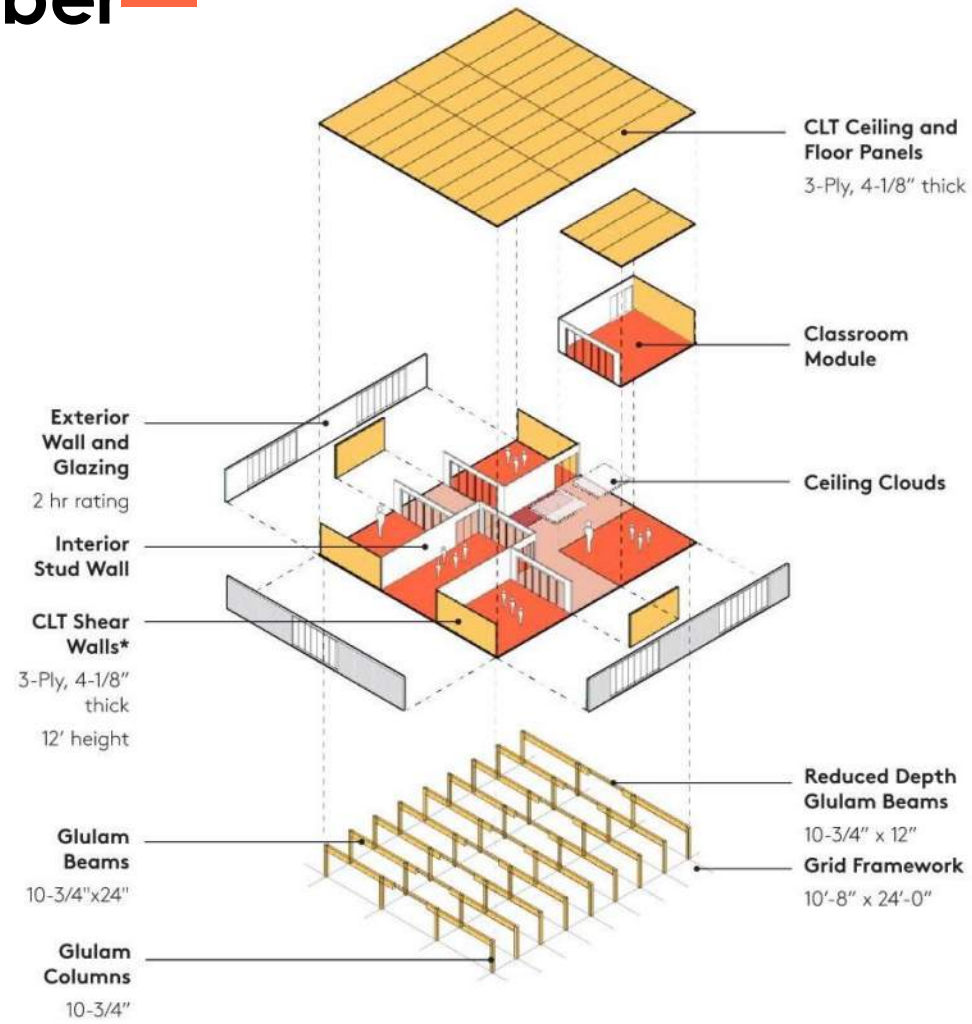


Variable Learning Blocks

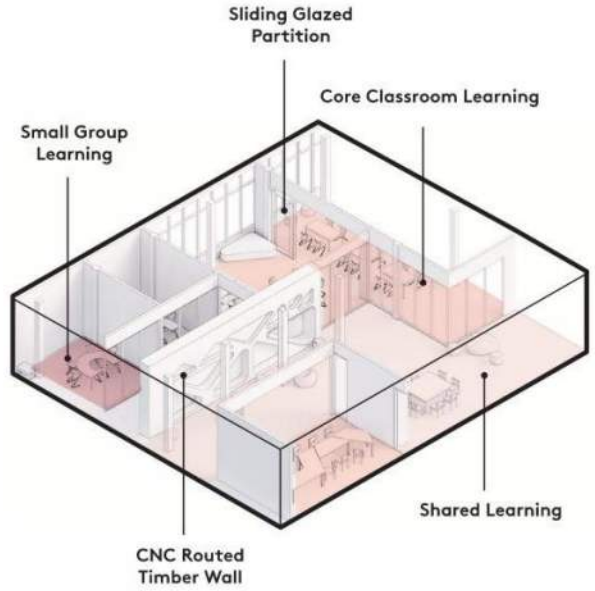


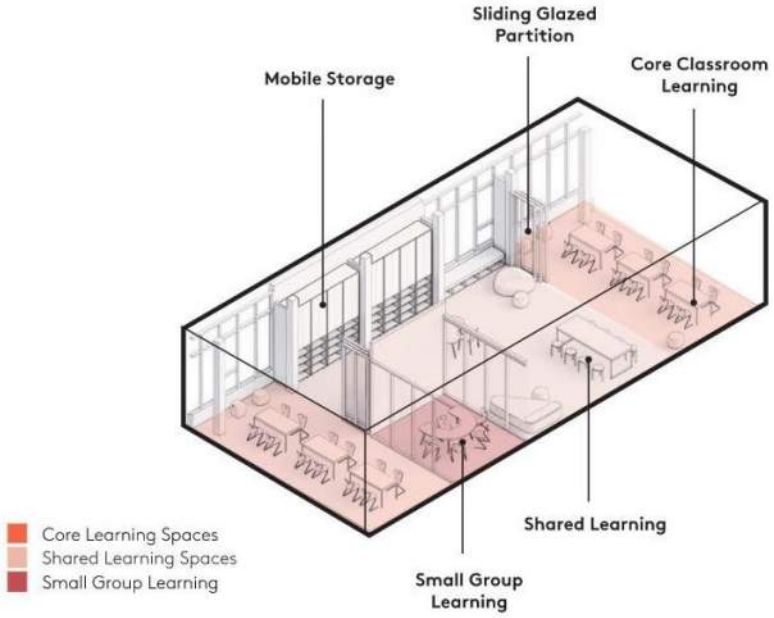
Designing with Mass Timber

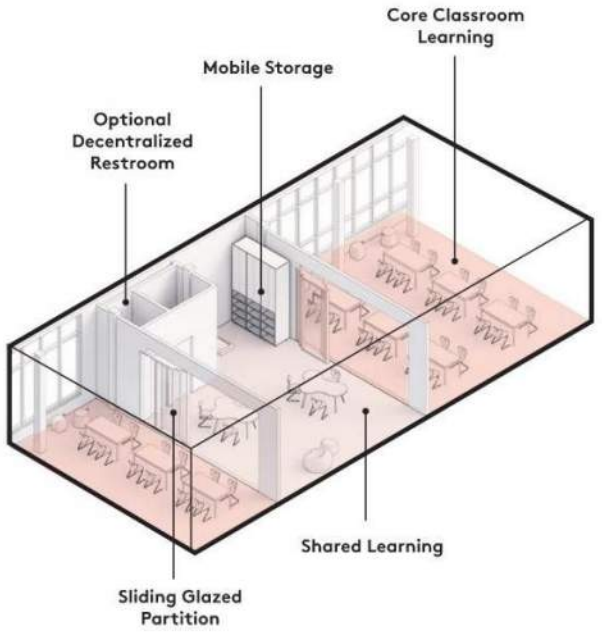




Adaptive Shared Learning Studies

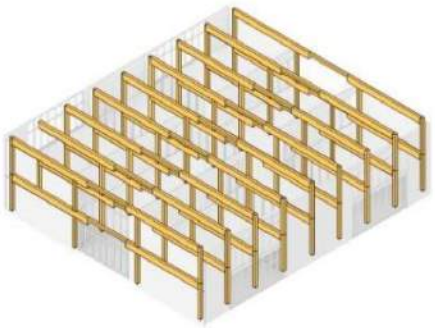




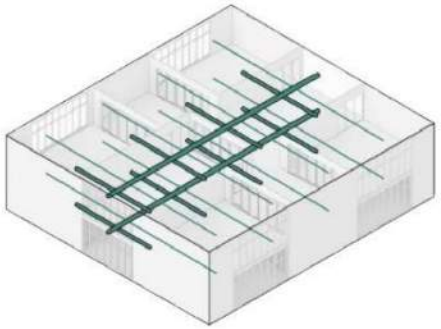


A Systems Based Approach

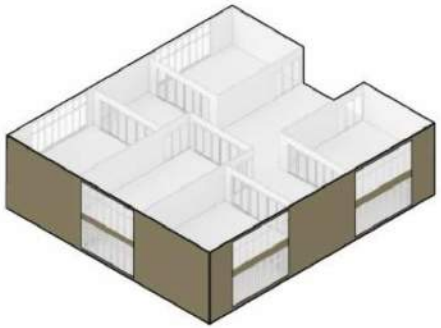
Structural "Bones"



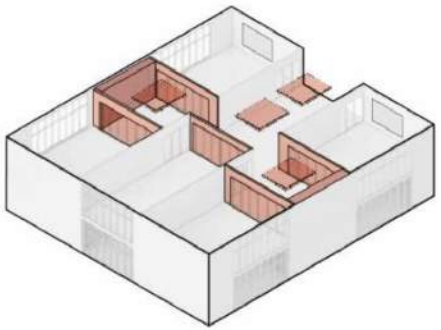
Mechanical System



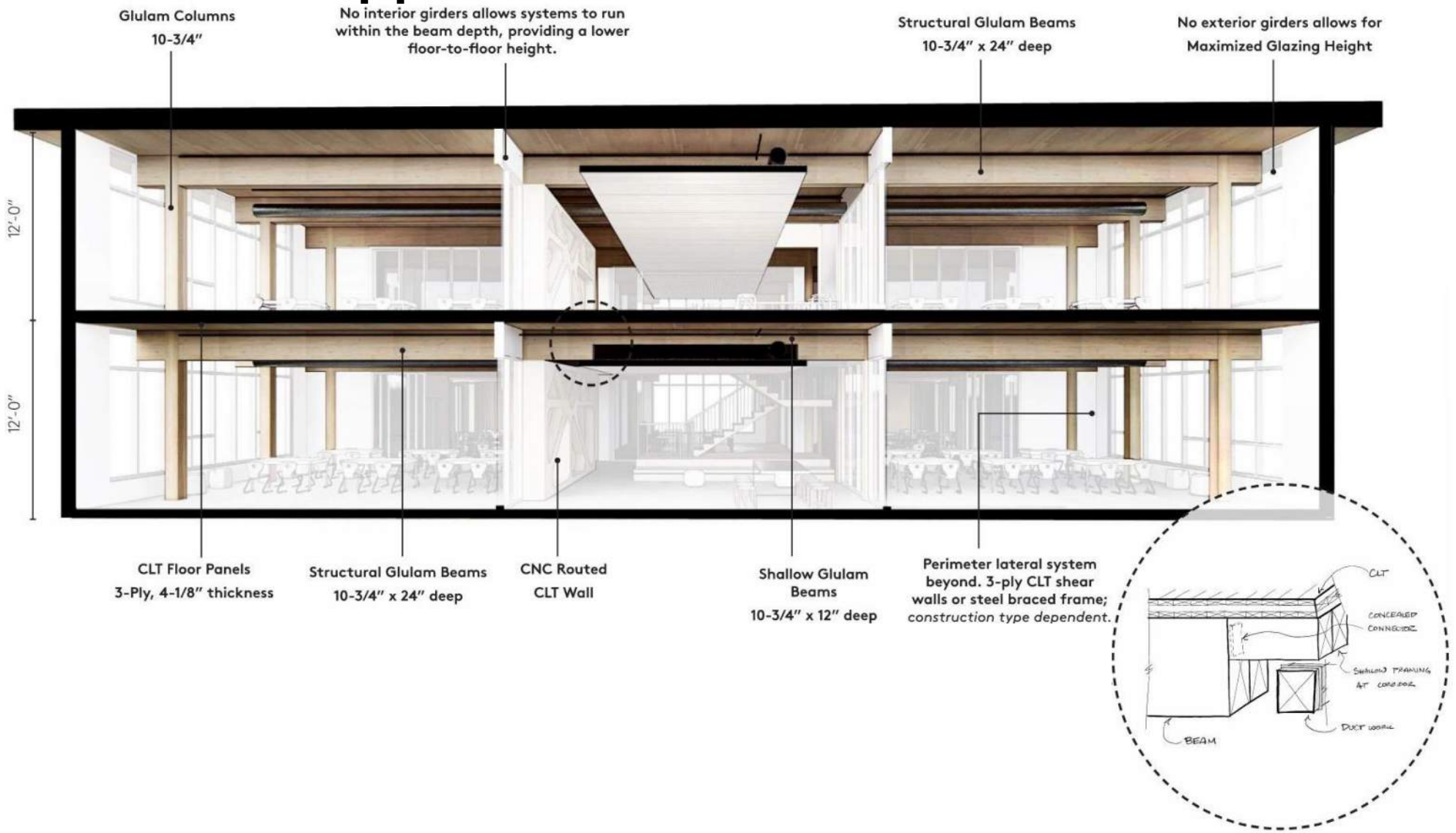
Exterior Enclosure



Interior Flexibility



A Systems Based Approach: Structure



Building Better Schools

There is a growing body of research that associates biophilic spaces with student health and cognitive benefits.

+

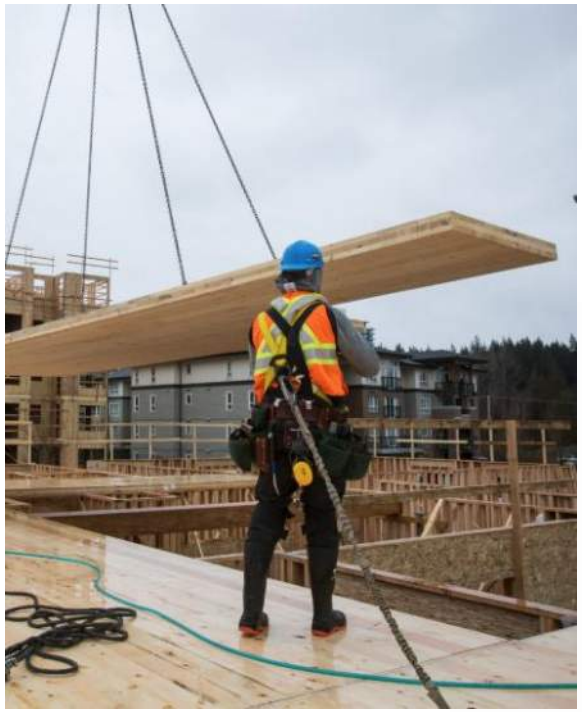
Emerging mass timber technology is positively impacting the way we design and construct buildings.

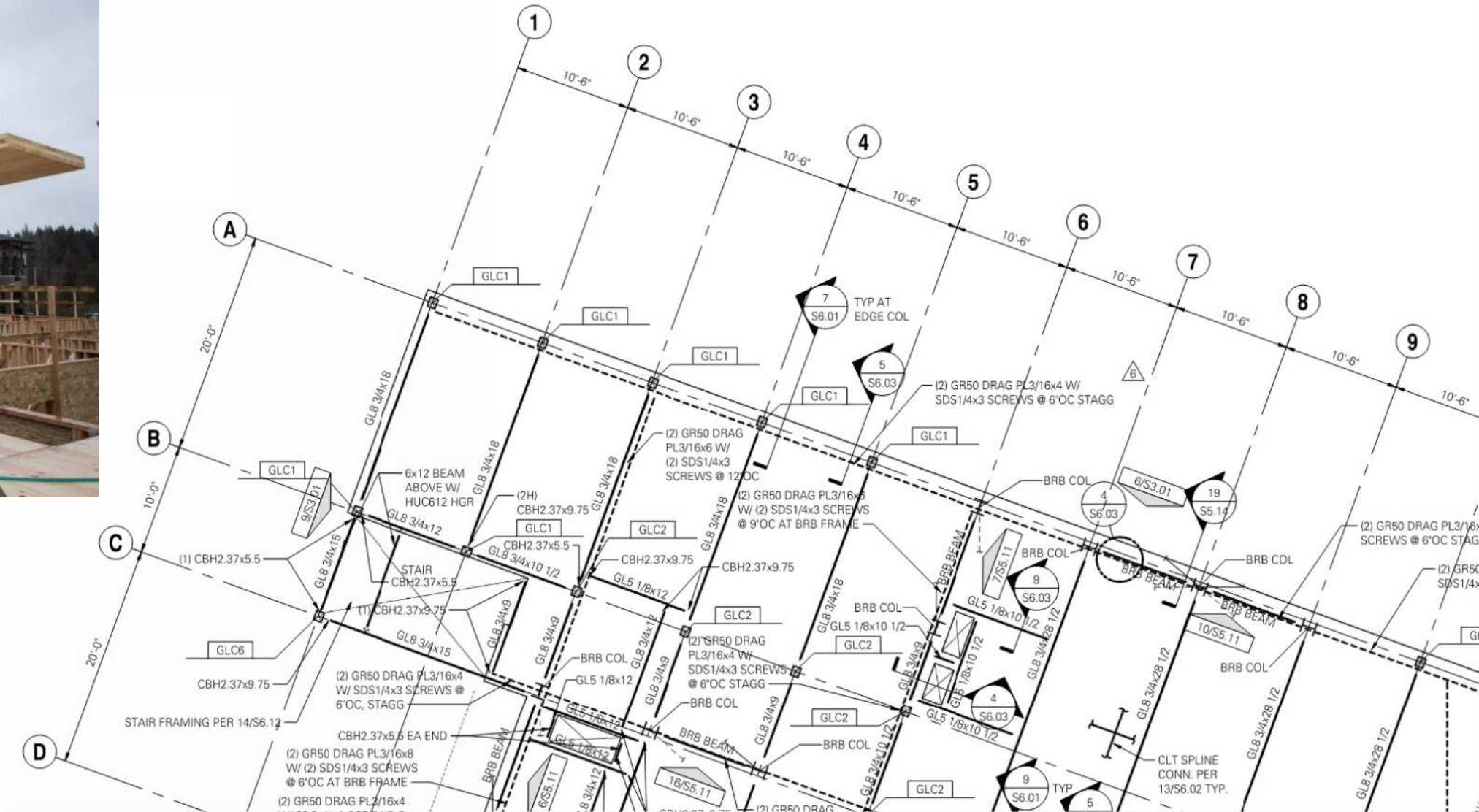
=

By combining timber technology and growing biophilic research, we can Build Better Schools.

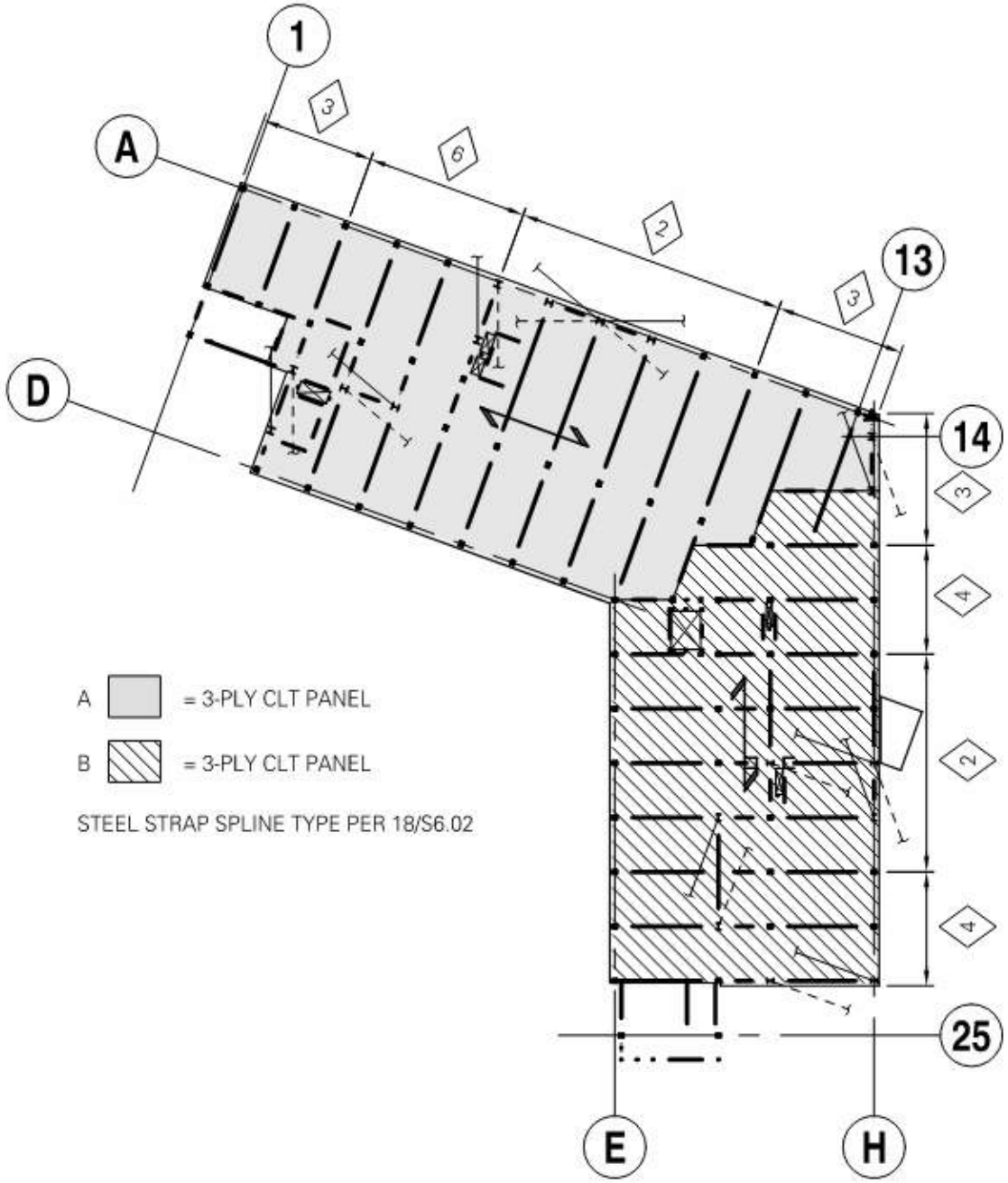
Bush Middle School Mass Timber

CLT 3-Ply Optimization





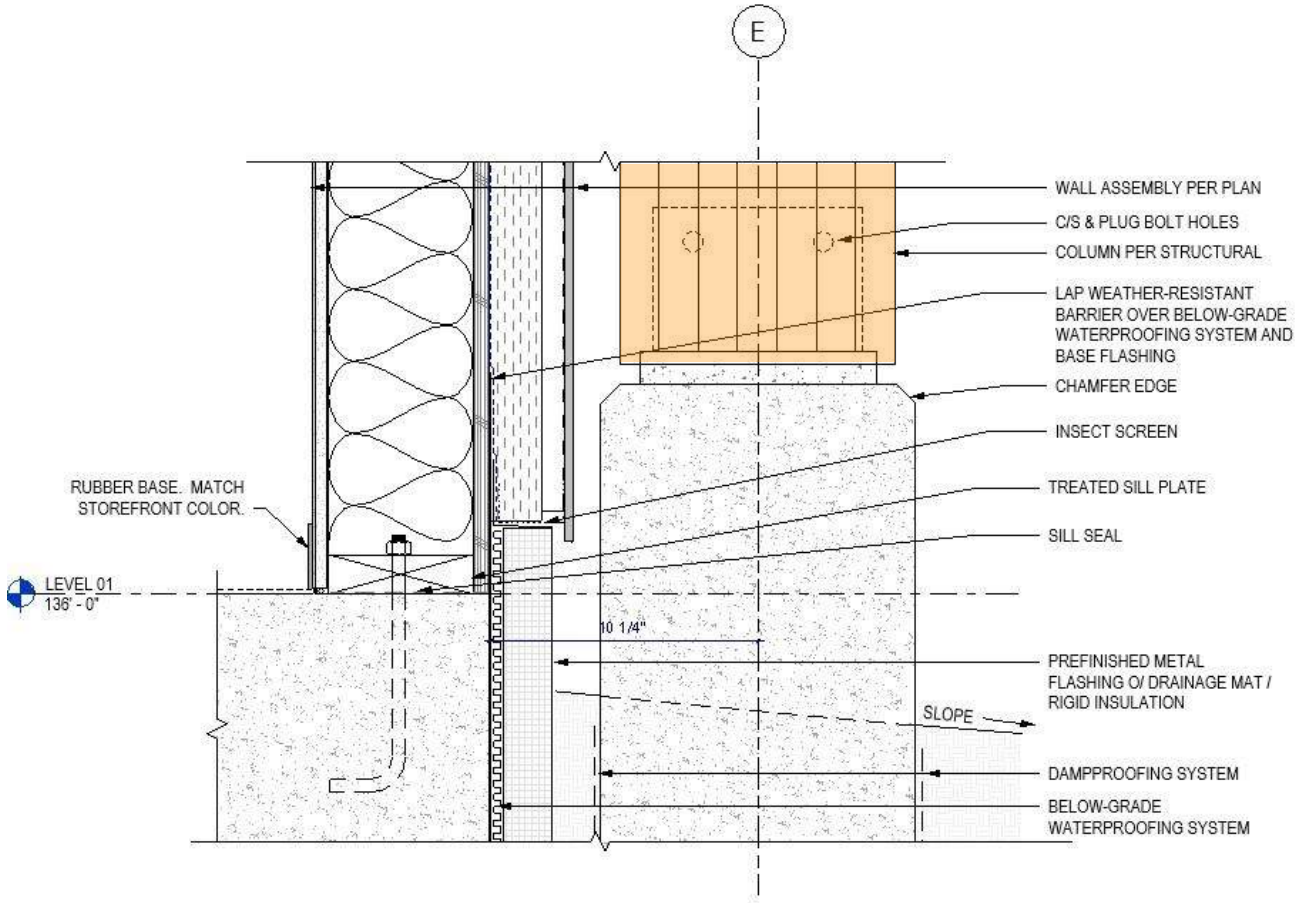
CLT Configuration



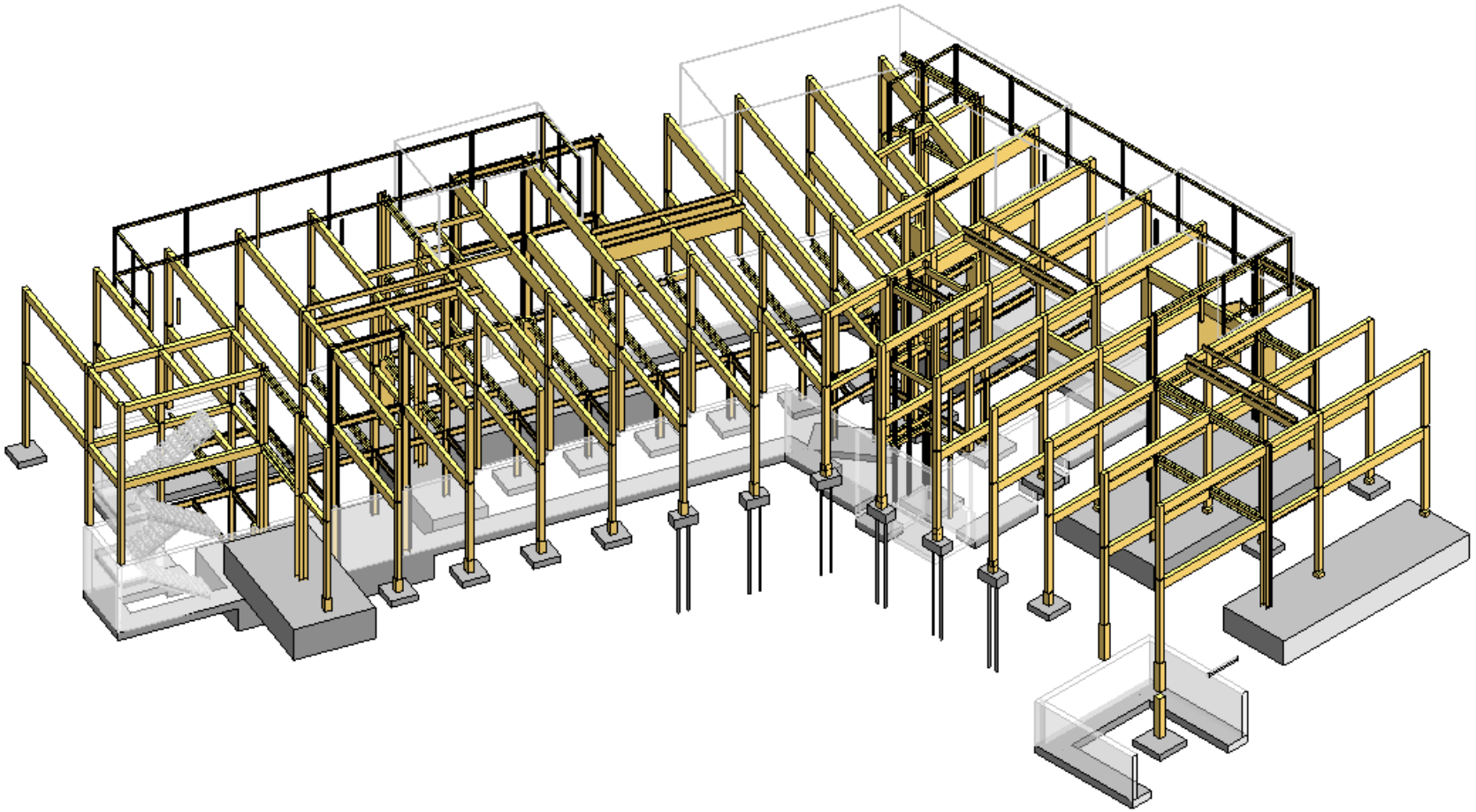
Glulam Beams & Columns

MASS TIMBER BASE DETAIL—

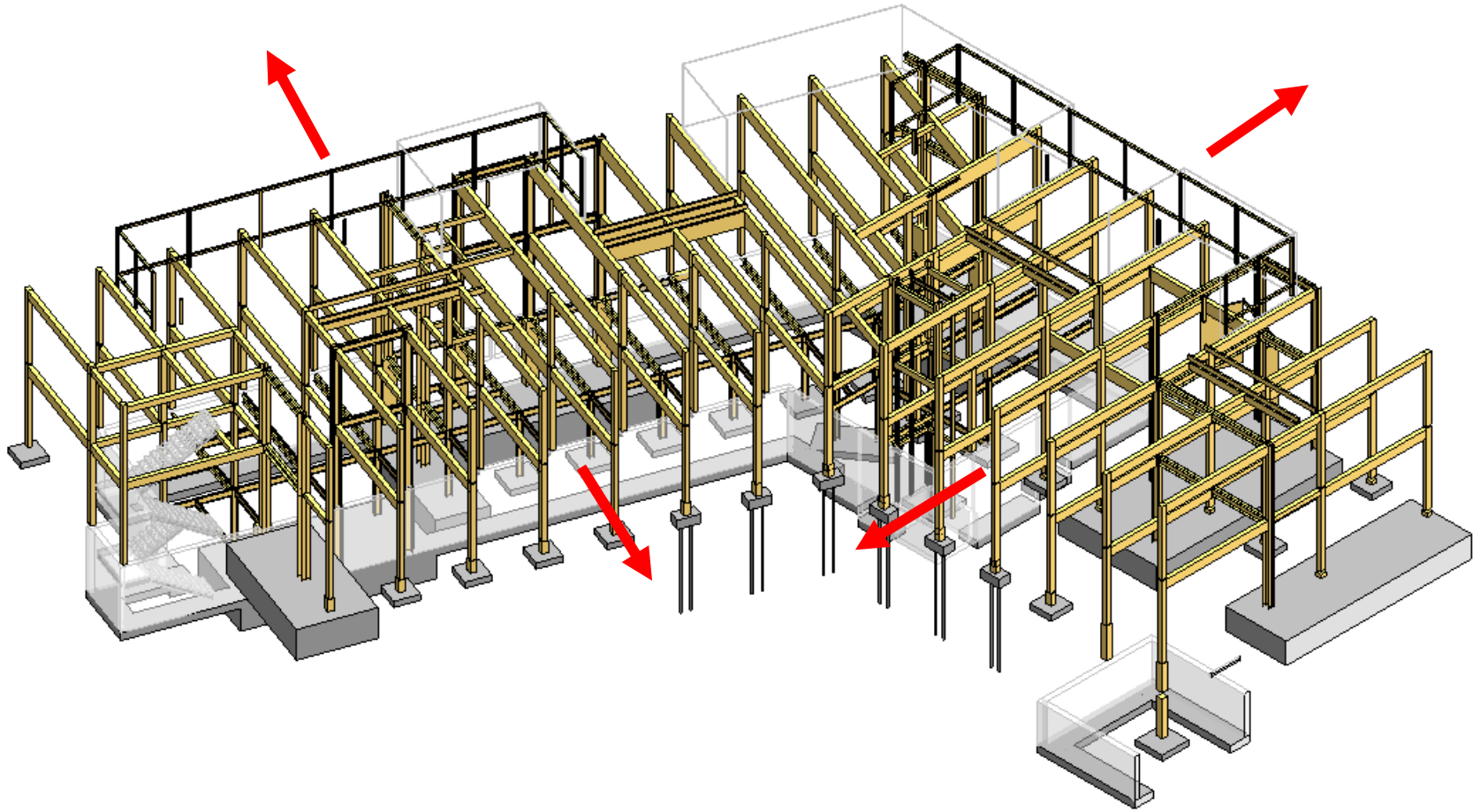
COLUMN BASE PROTECTION



Clear Perimeter—



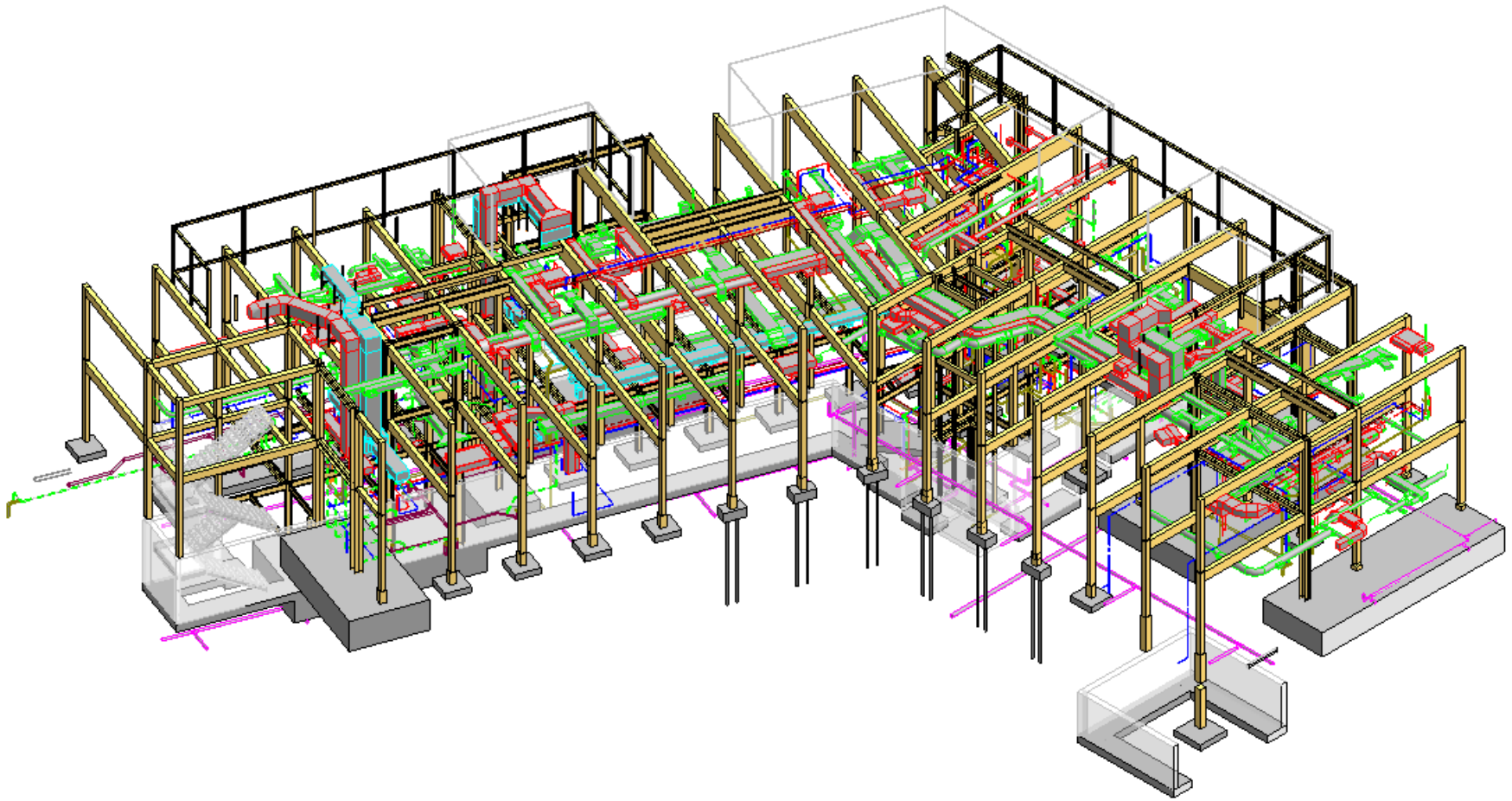
Clear Perimeter—



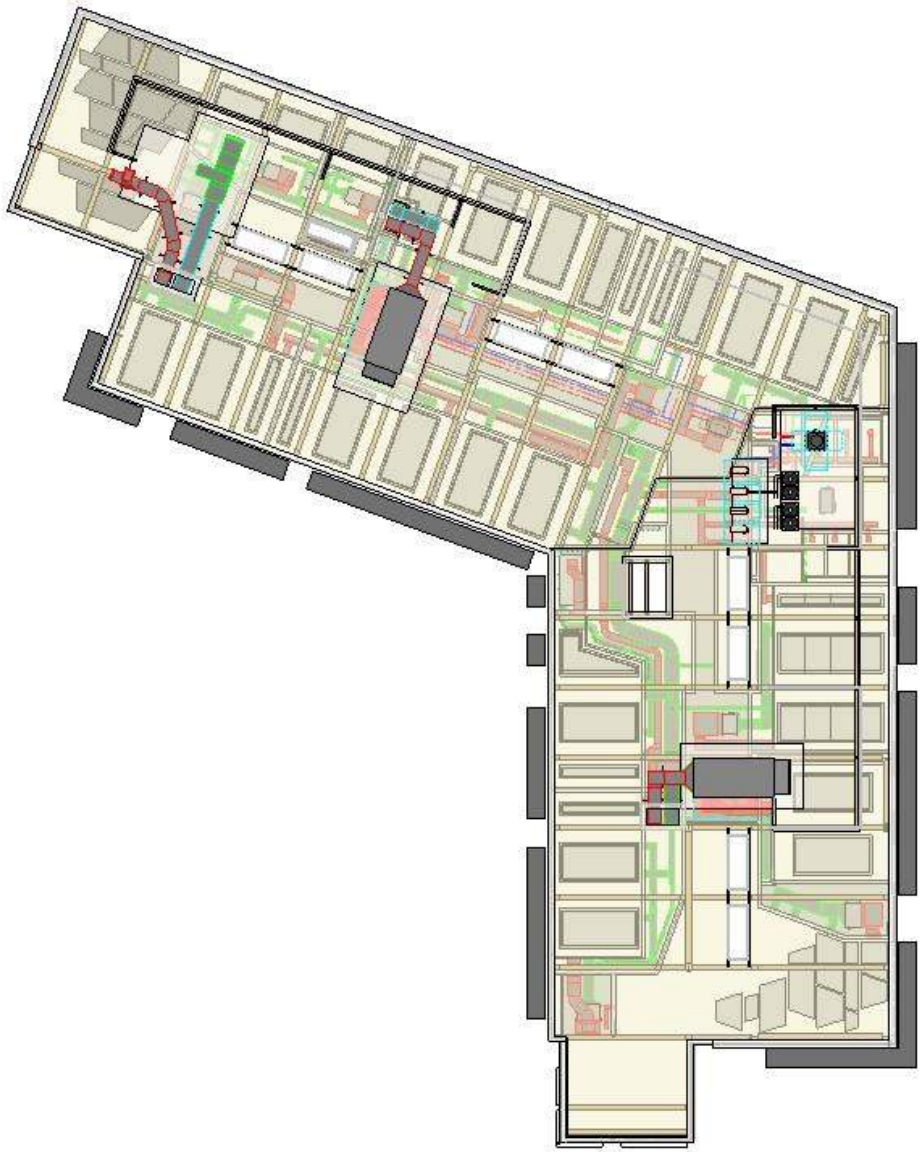
Optimized Daylight

Washington School for the Deaf
Vancouver, Washington

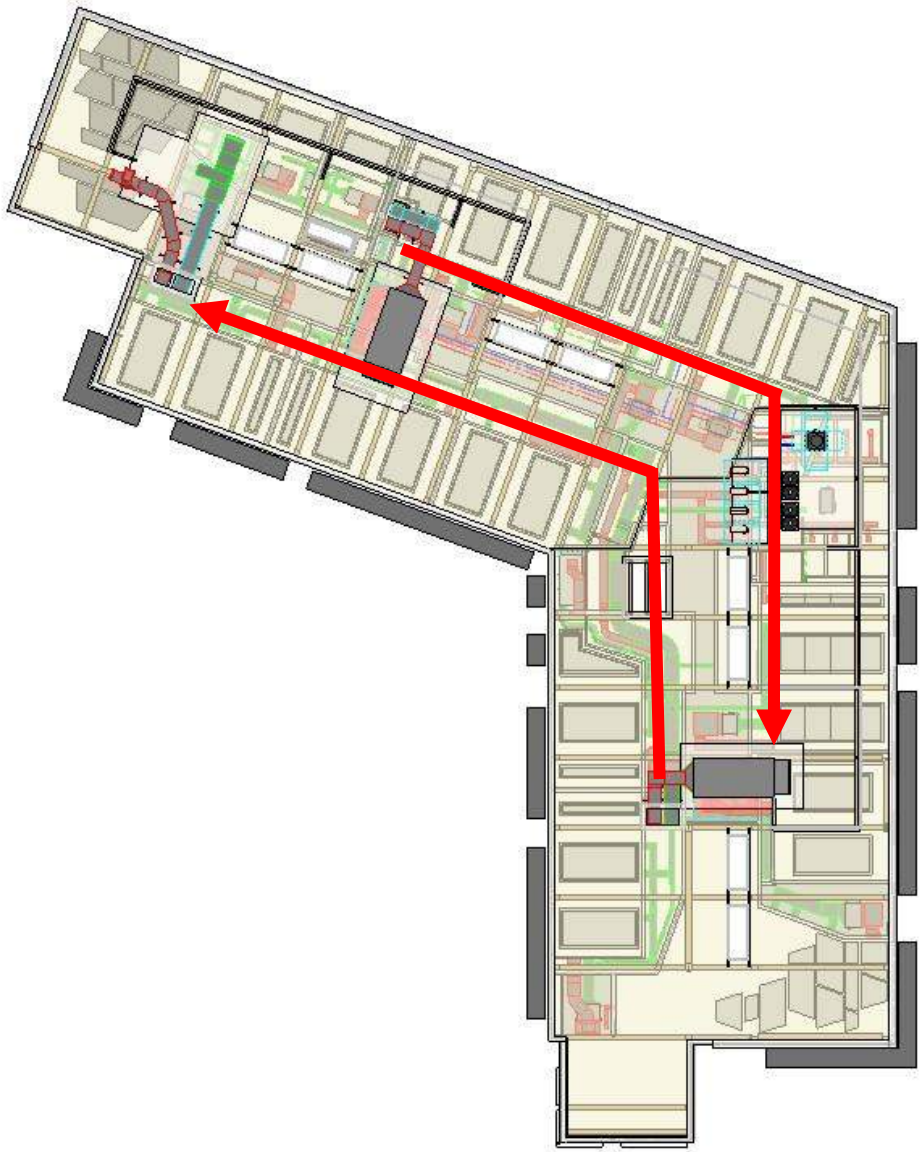
MEP/BIM Coordination



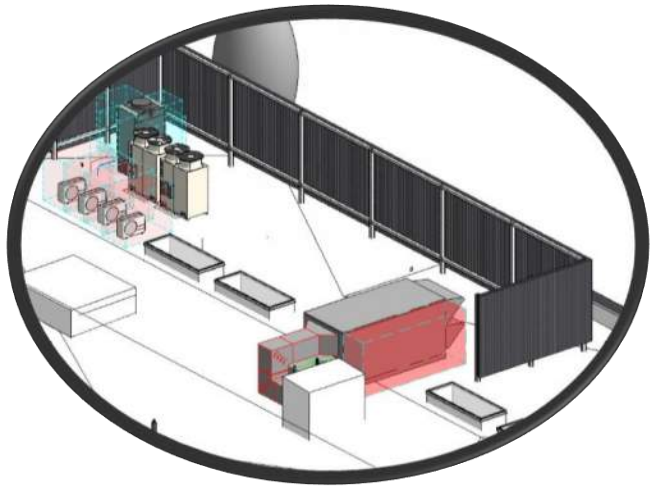
MEP ROUTING

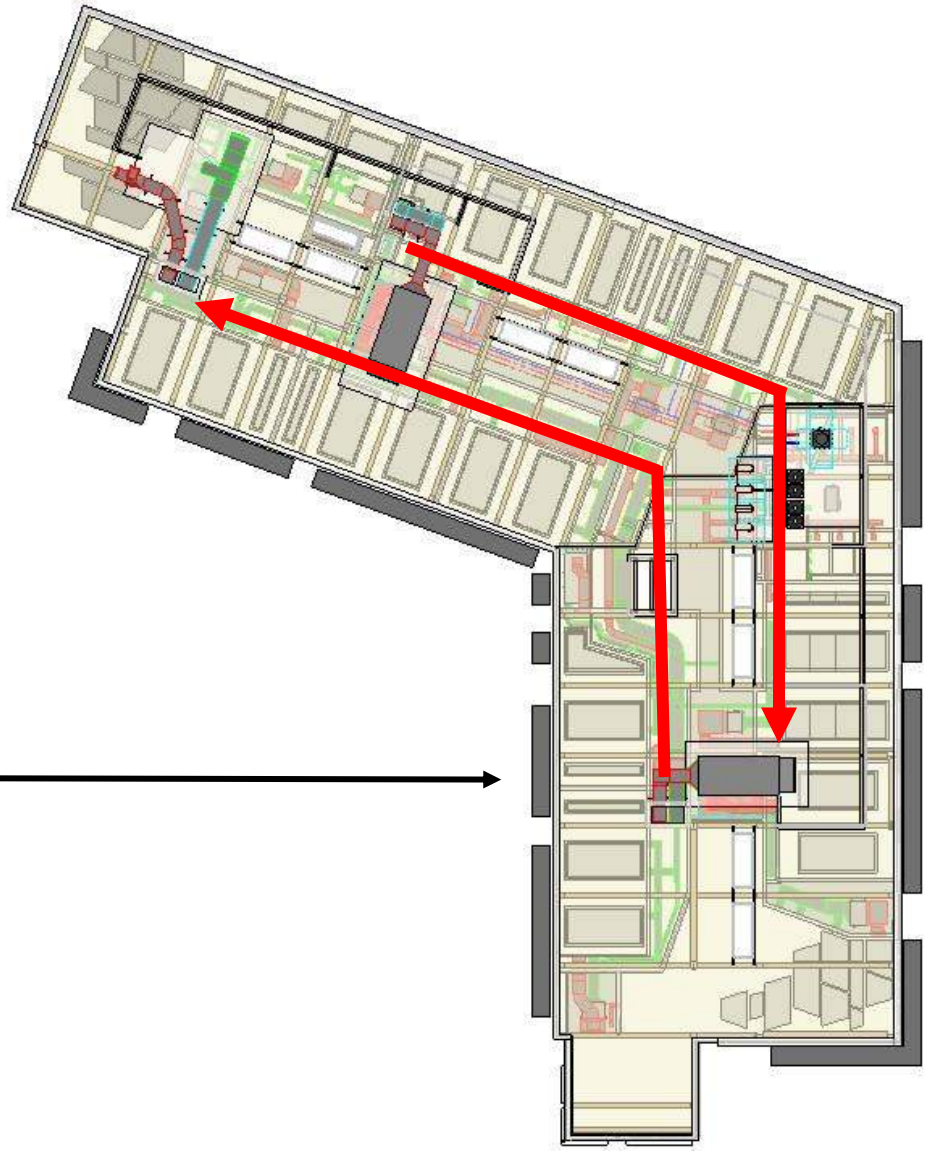


MEP ROUTING



MEP ROUTING



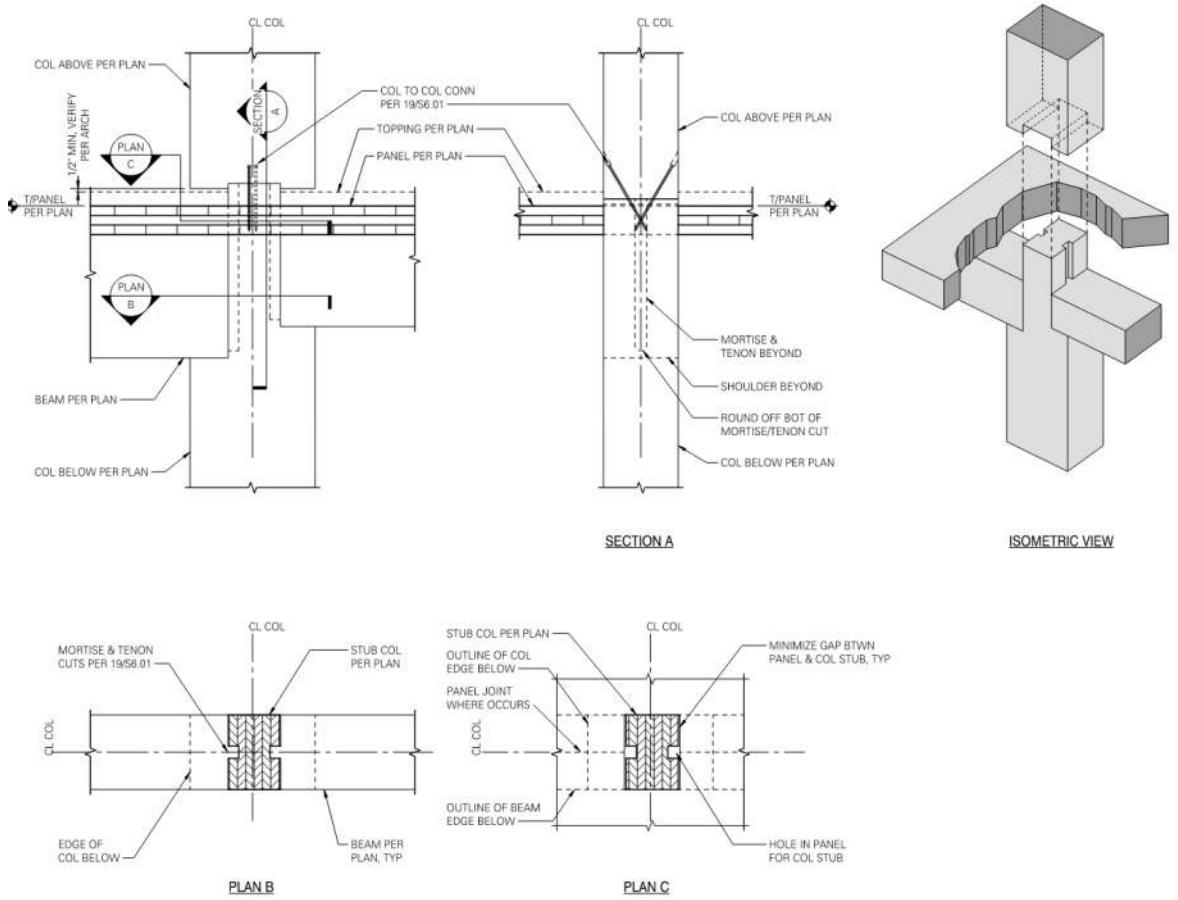


Daylight Access

Interior Skylight

Mass Timber Connections

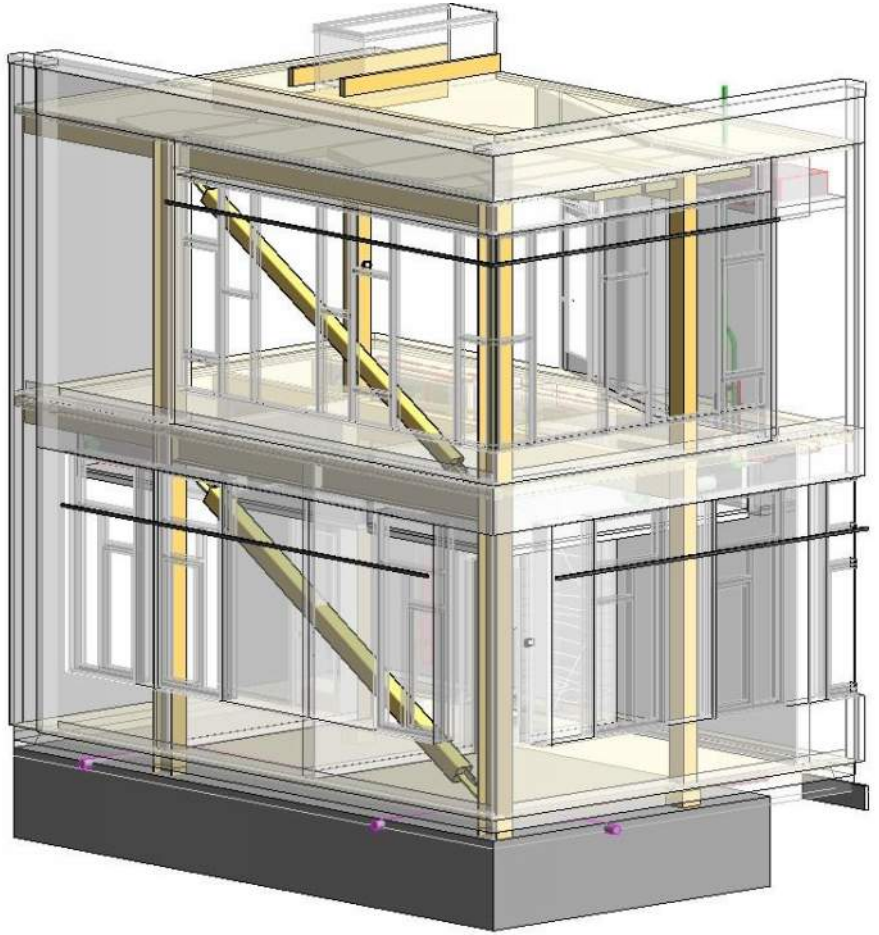
Mortise & Tenon Joint

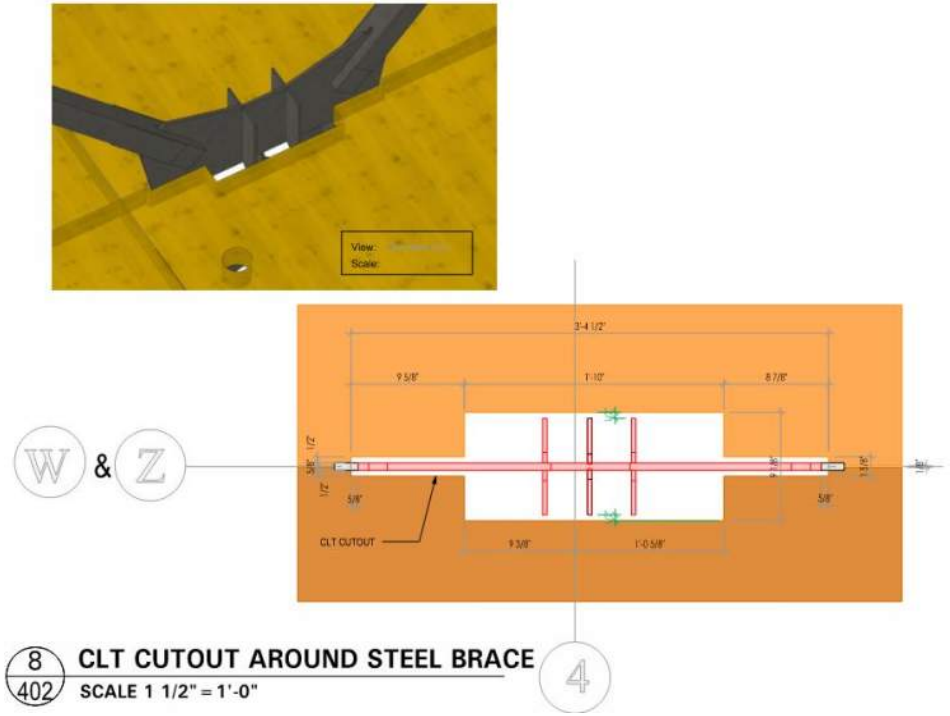


9 **WOOD BEAM TO COLUMN CONNECTION - DIFFERENT DEPTH BEAMS**

SCALE: 1" = 1'-0" (09151A)

Mass Timber Shop Drawings





CLT & Steel Lateral Bracing

Embodied Health & Carbon—

Biophilia—

The biophilia hypothesis (BET) suggests that humans possess an innate tendency to seek connections with nature and other forms of life.

Sense of Home

Connection to Wood

Washington School for the Deaf
Vancouver, Washington

Connection to Wood

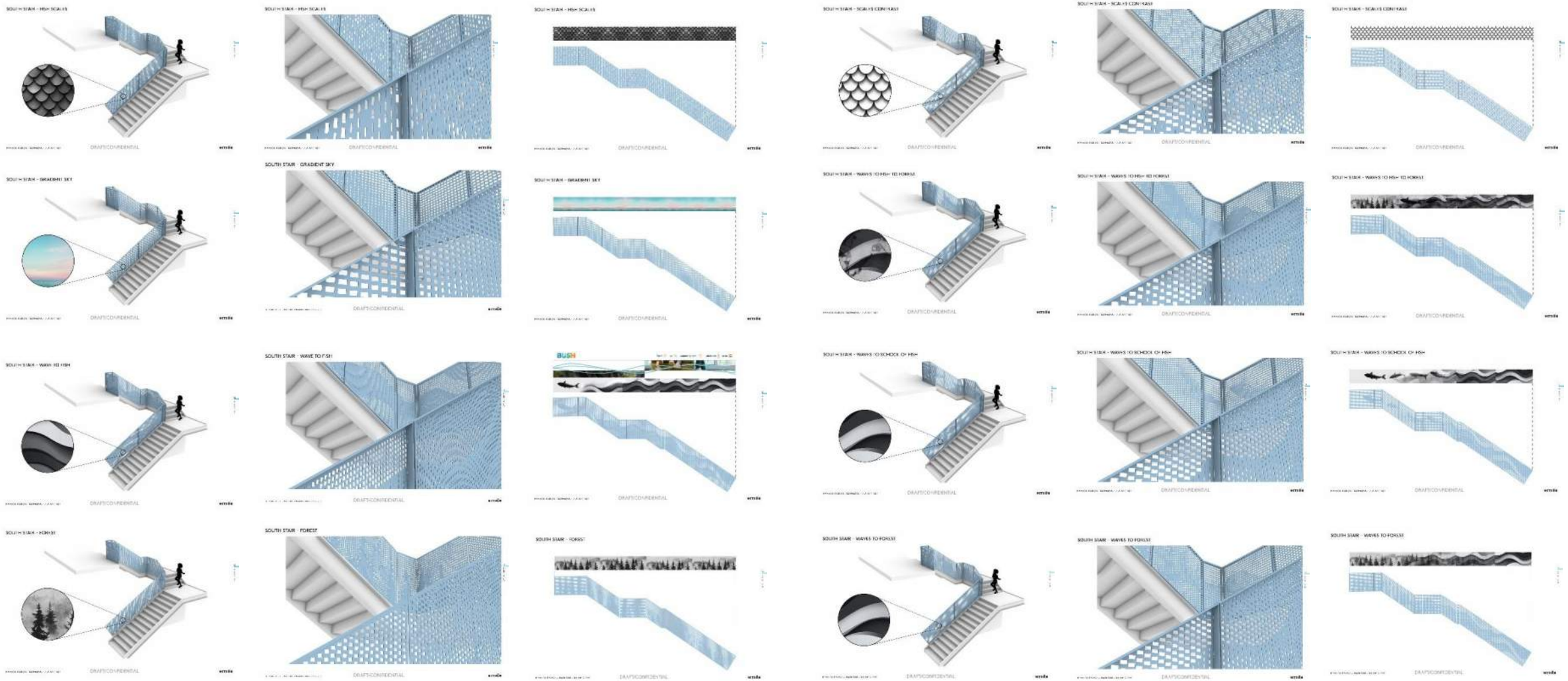
Mass Plywood Panel (Built-Ins)

Mass Plywood Panel (Built-Ins)

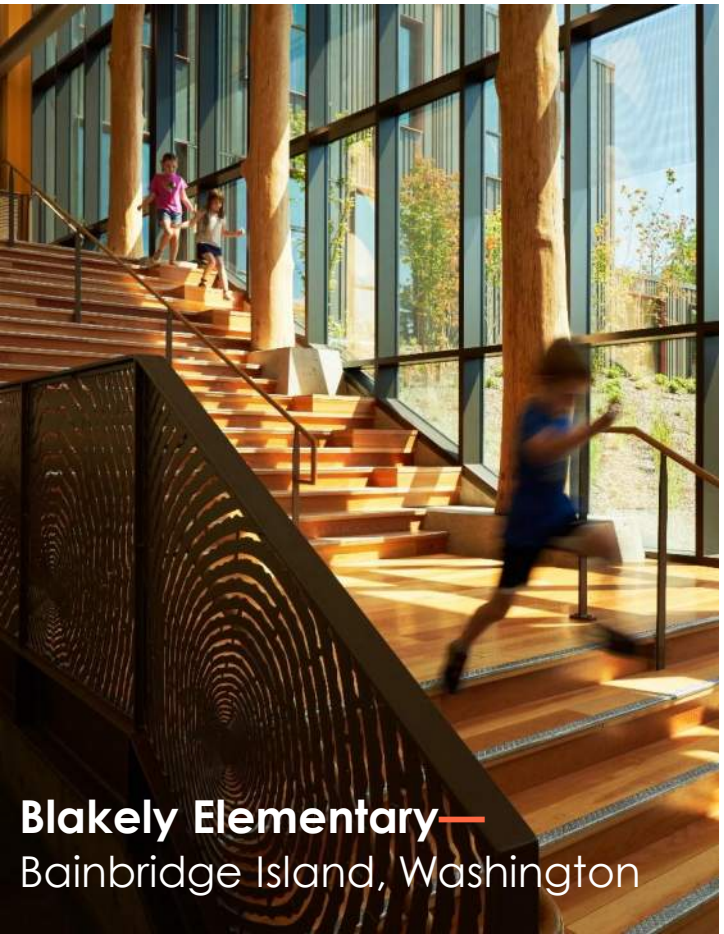
The Bush School
Upper School Expansion
Seattle, WA

CLT Stair (Off-Cuts)

Biophilic Stair Studies



DNA—



Blakely Elementary—
Bainbridge Island, Washington

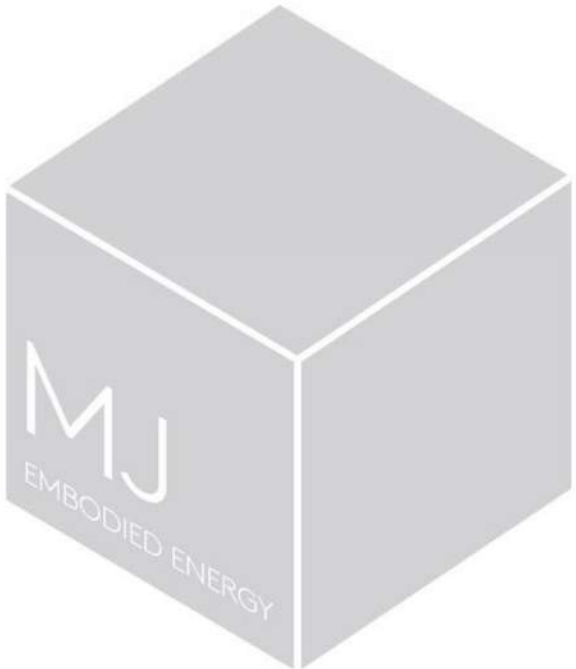
Overlake School—
Redmond, Washington

Net Zero Carbon

ZERO CARBON CERTIFICATION

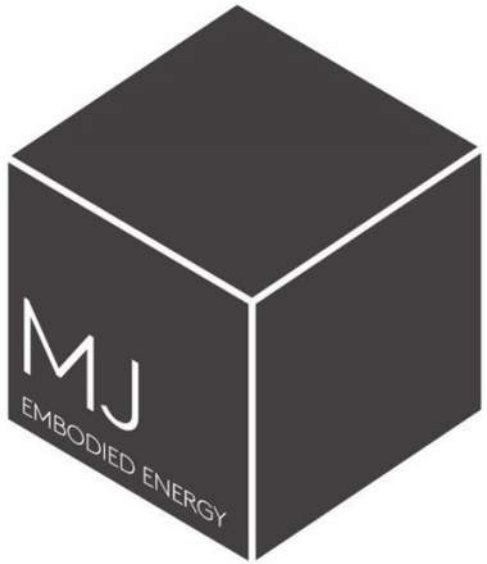
Embodied Carbon

- The embodied carbon emissions of primary materials must be reduced by 10% compared to a baseline building of equivalent size, function, and energy performance.
- The total embodied carbon of the project building may not exceed 500kg CO2e/m2.
- One hundred percent of the embodied carbon emissions impacts associated with the construction and materials of the project must be disclosed and offset through the use of on-site carbon-sequestering materials or by a one-time purchase of carbon offsets from an ILFI-approved source.



CONCRETE

12.5 MJ / kg Embodied Energy



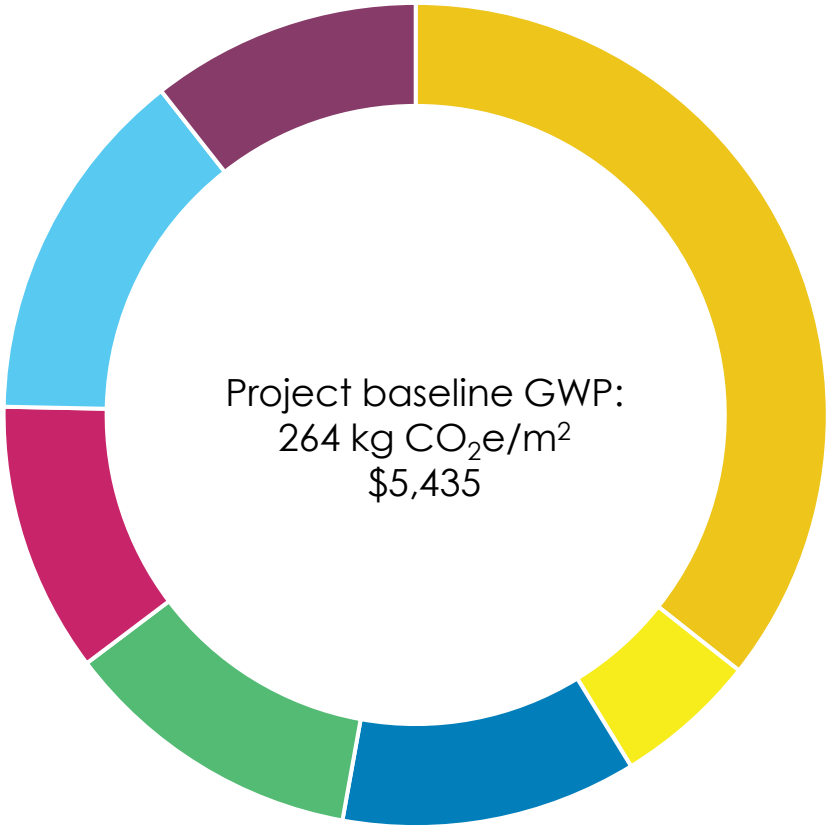
STEEL

10.5 MJ / kg Embodied Energy

WOOD

2.0 MJ / kg Embodied Energy

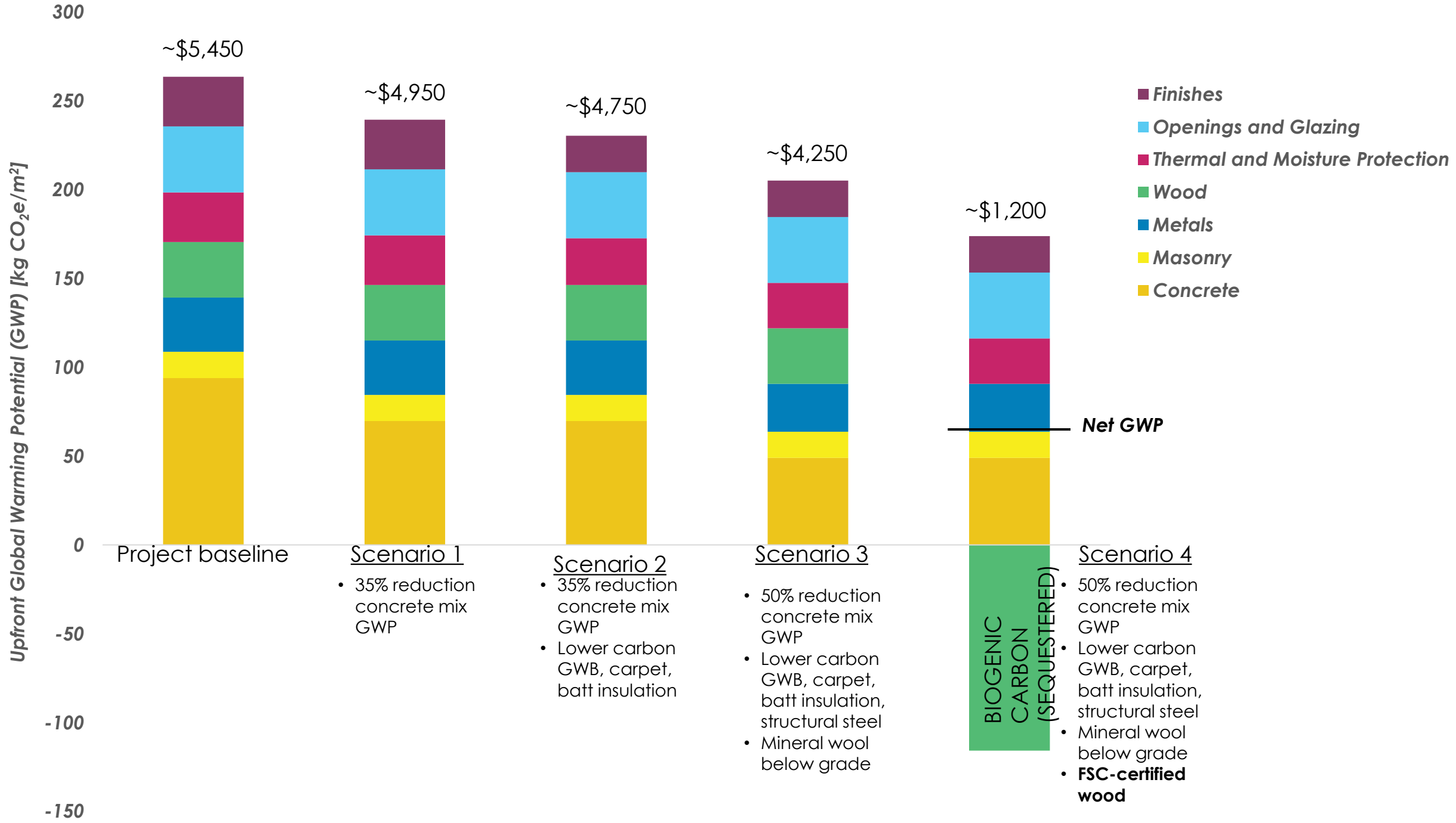
Net Zero Carbon



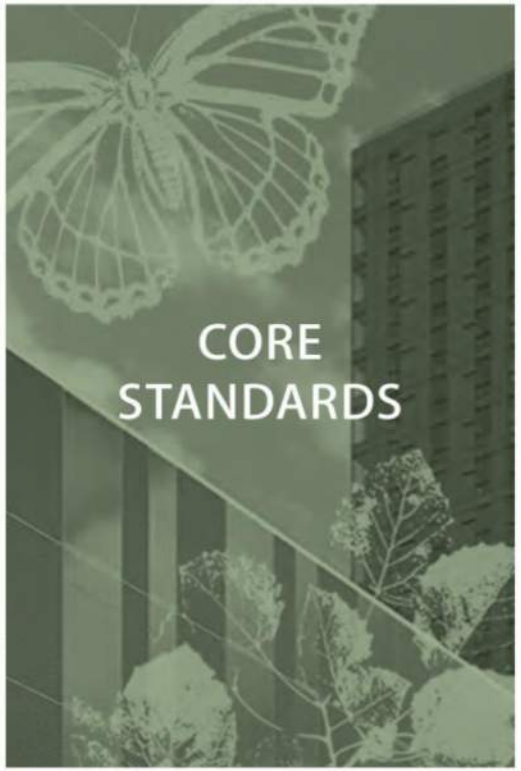
- *Concrete*
- *Masonry*
- *Metals*
- *Wood*
- *Thermal and Moisture Protection*
- *Openings and Glazing*
- *Finishes*

TOP 10 IMPACTS

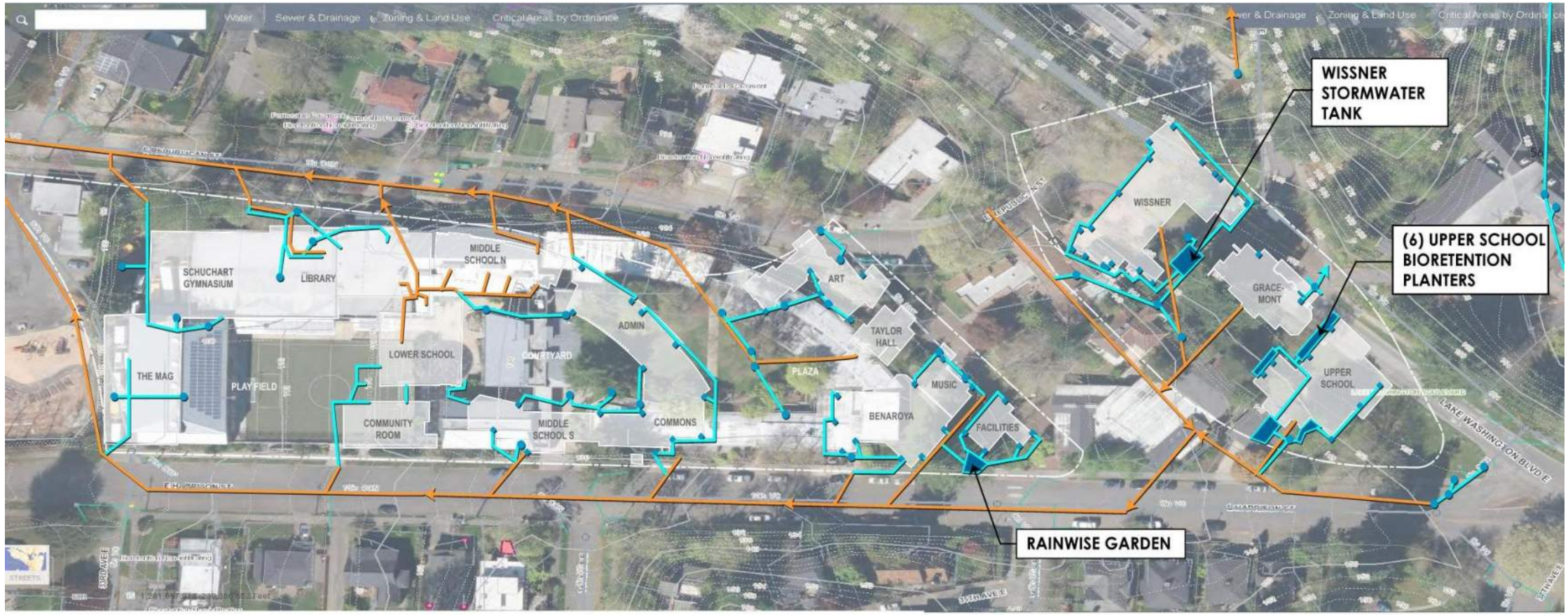
- FOUNDATIONS
- CONCRETE WALLS
- TOPPING SLABS
- CLT
- SLAB ON GRADE
- POLYISO ROOF INSULATION
- BRICK
- ALUMINUM MULLIONS
- STRUCTURAL STEEL – WIDE FLANGES
- GYPSUM WALL BOARD


300
250
200
150
100
50
0
-50
-100
-150
Upfront Global Warming Potential (GWP) [kg CO2e/m2]
~$5,450
~$4,950
~$4,750
~$4,250
~$1,200
Finishes
Openings and Glazing
Thermal and Moisture Protection
Wood
Metals
Masonry
Concrete
Net GWP
BIOGENIC CARBON (SEQUESTERED)
Project baseline
Scenario 1
• 35% reduction concrete mix GWP
Scenario 2
• 35% reduction concrete mix GWP
• Lower carbon GWB, carpet, batt insulation
Scenario 3
• 50% reduction concrete mix GWP
• Lower carbon GWB, carpet, batt insulation, structural steel
• Mineral wool below grade
Scenario 4
• 50% reduction concrete mix GWP
• Lower carbon GWB, carpet, batt insulation, structural steel
• Mineral wool below grade
• FSC-certified wood

Salmon-Safe Urban Standards 3.0

#	Management Category	Context
U.1	Stormwater Management	
U.2	Water Use Management	
U.3	Erosion Prevention and Sediment Control	
U.4	Pesticide Reduction and Water Quality Protection in Landscaping	
U.5	Enhancement of Urban Ecological Function	
U.6	Site Climate Resiliency Planning	

Campus Stormwater— 100% Retention On-Site (Campus)



Salmon Safe

- Bioretention

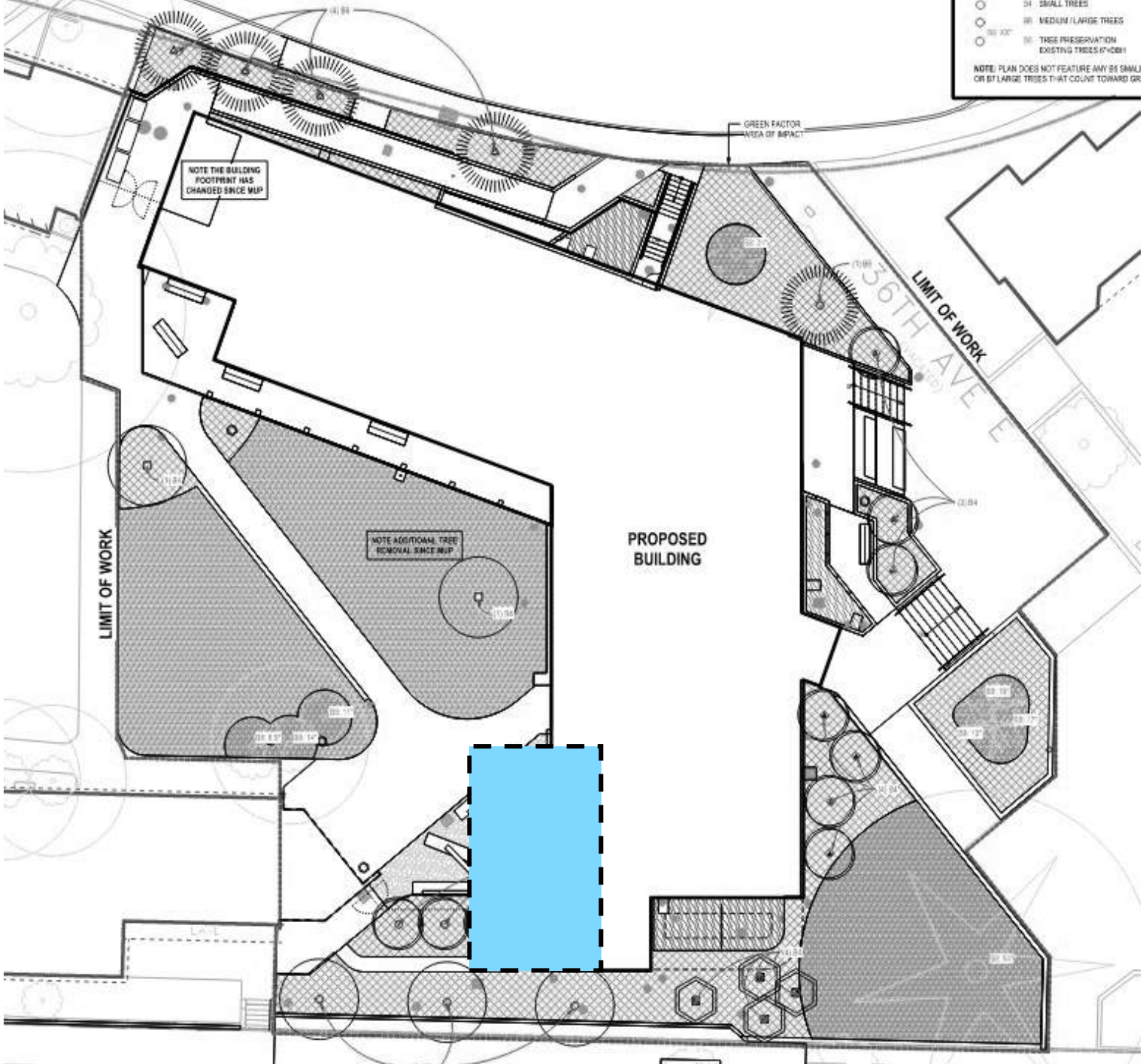
  100% Retention On-Site

Salmon Safe

- Bioretention

  100% Retention On-Site

- Stormwater Detention Vault



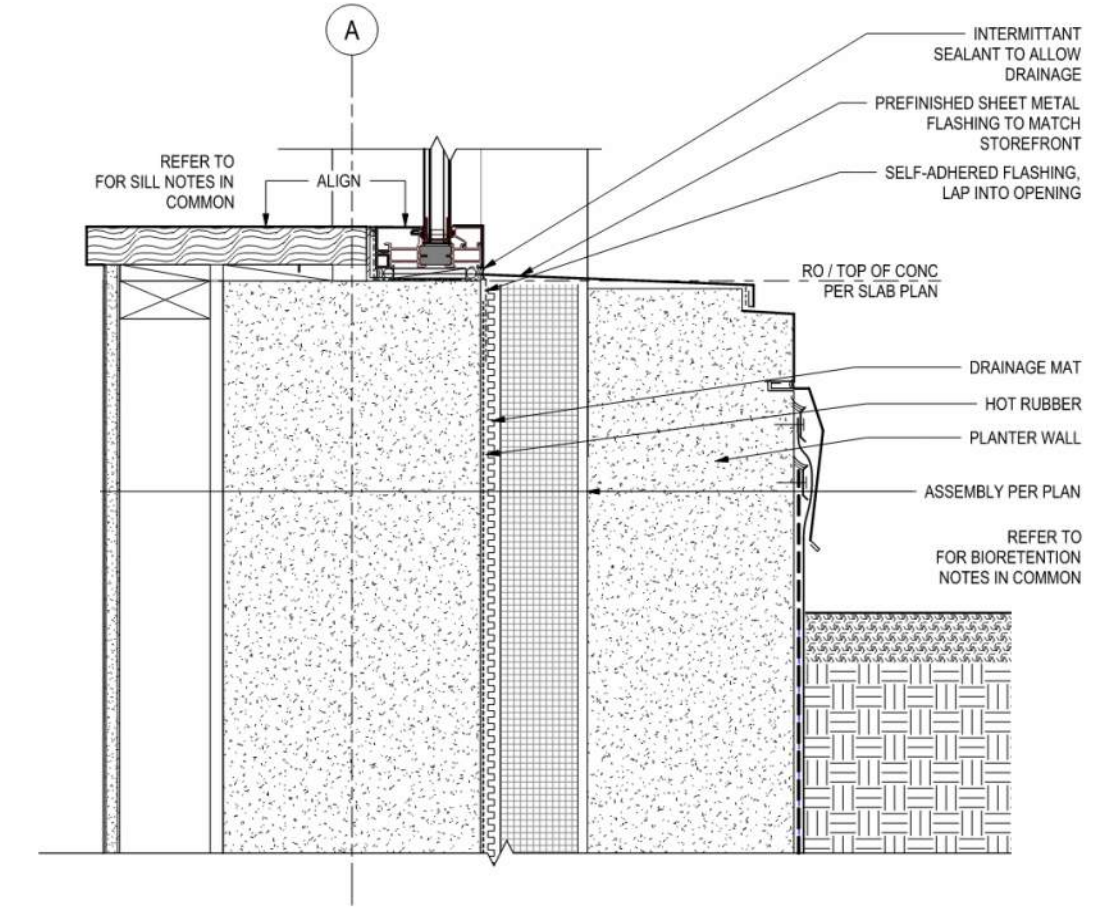
Salmon Safe

- Bioretention Details

  100% Retention On-Site

- Stormwater Detention Vault

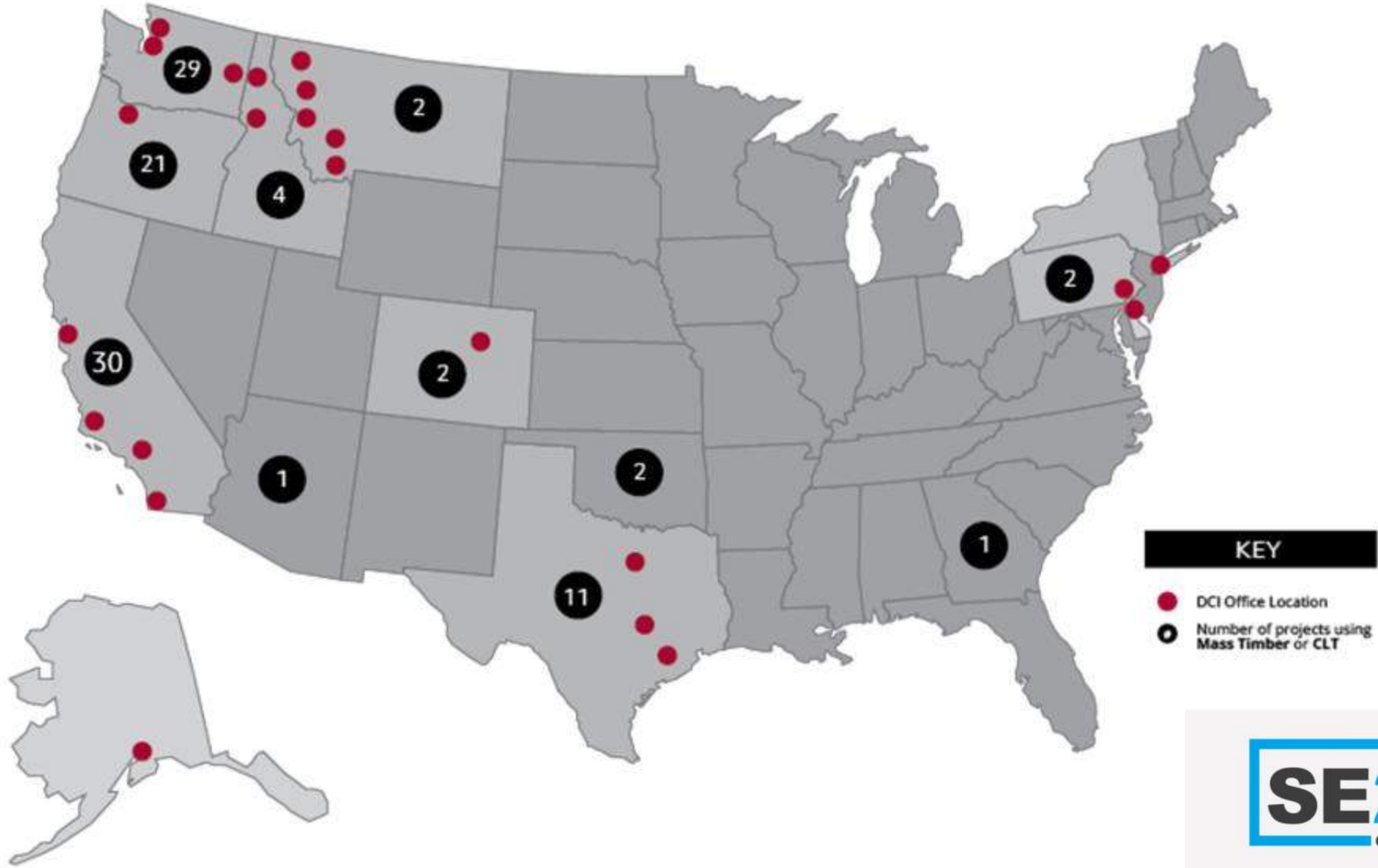
- Integrated Design Team



Bioretention

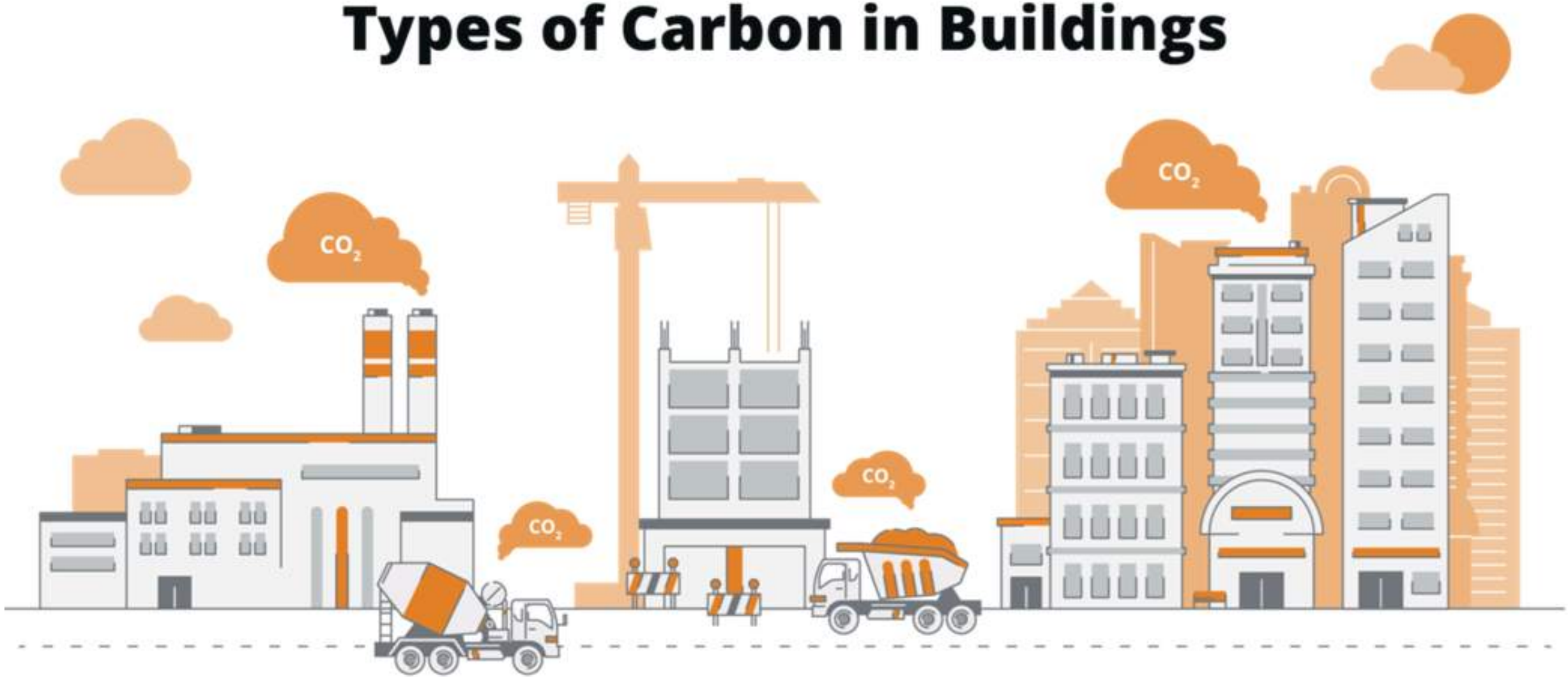
DCI LCA Comparative Analysis

DCI MASS TIMBER PROJECT MAP



SE2050
COMMITTING TO ZERO

Types of Carbon in Buildings

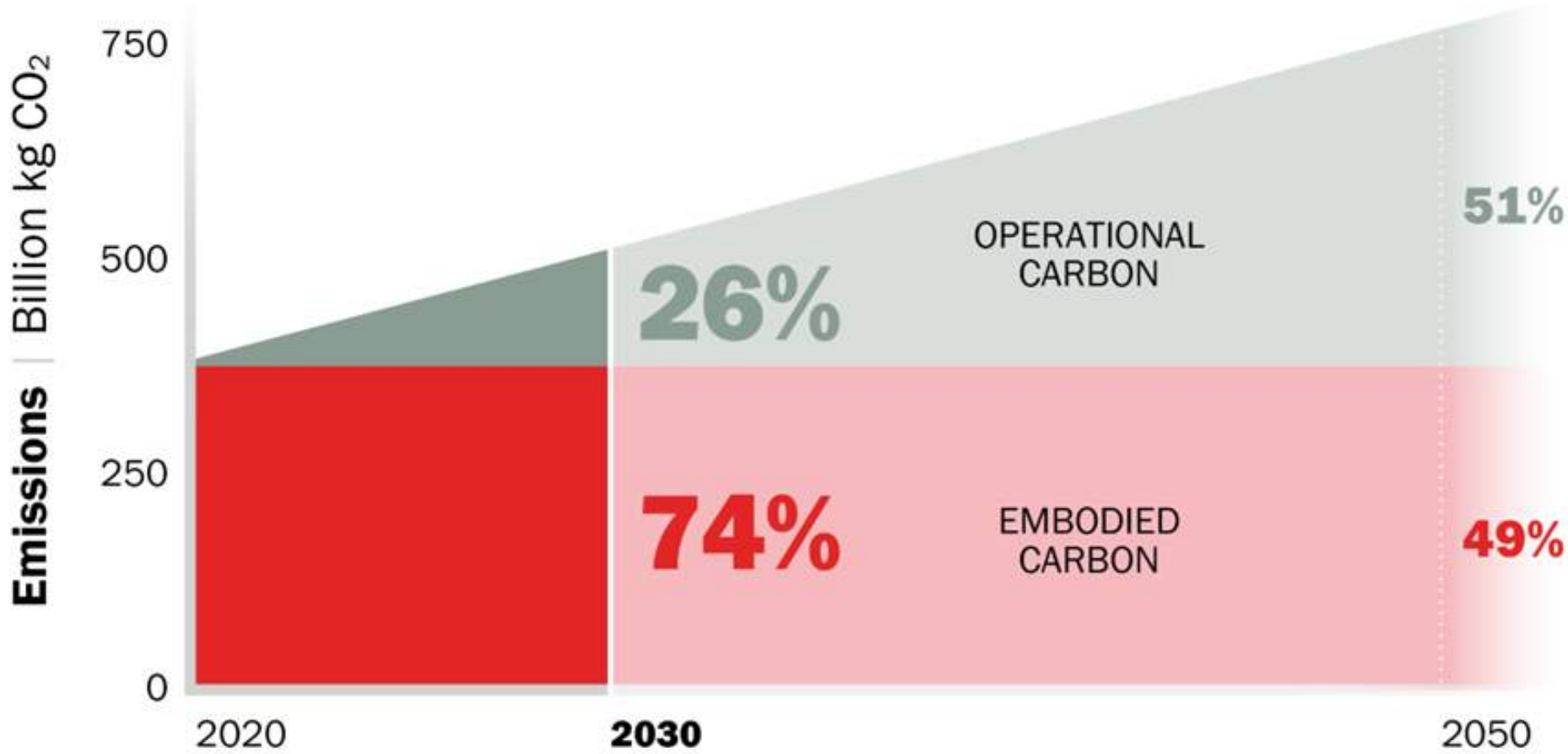


Embodied Carbon
The emissions from manufacturing, transportation, and installation of building materials.

Operational Carbon
The emissions from a building's energy consumption.

Source: CarbonCure Technologies, 2020

Total Carbon Emissions of Global New Construction from 2020–2050



DATA SOURCE: ARCHITECTURE 2030

DRIVING FUTURE INNOVATION

Green Building Ratings

- LEEDv5
  - required embodied carbon assessment
- ILFI

Building Codes

- ACI 323 Low-Carbon Concrete Code
- CLF North American Benchmark Study

Legislation & Incentive Programs

- BuyClean, CALGreen
- Boston NetZero Carbon Zoning Initiative
- NYC Mass Timber Studio

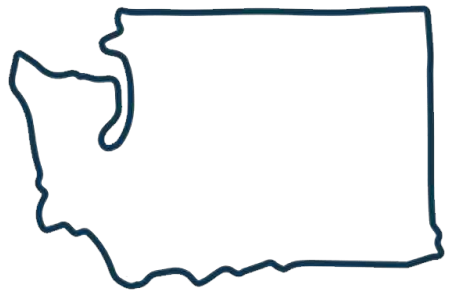
LEED V5

CLF WBLCA Benchmark Study V2

NYC / EDC

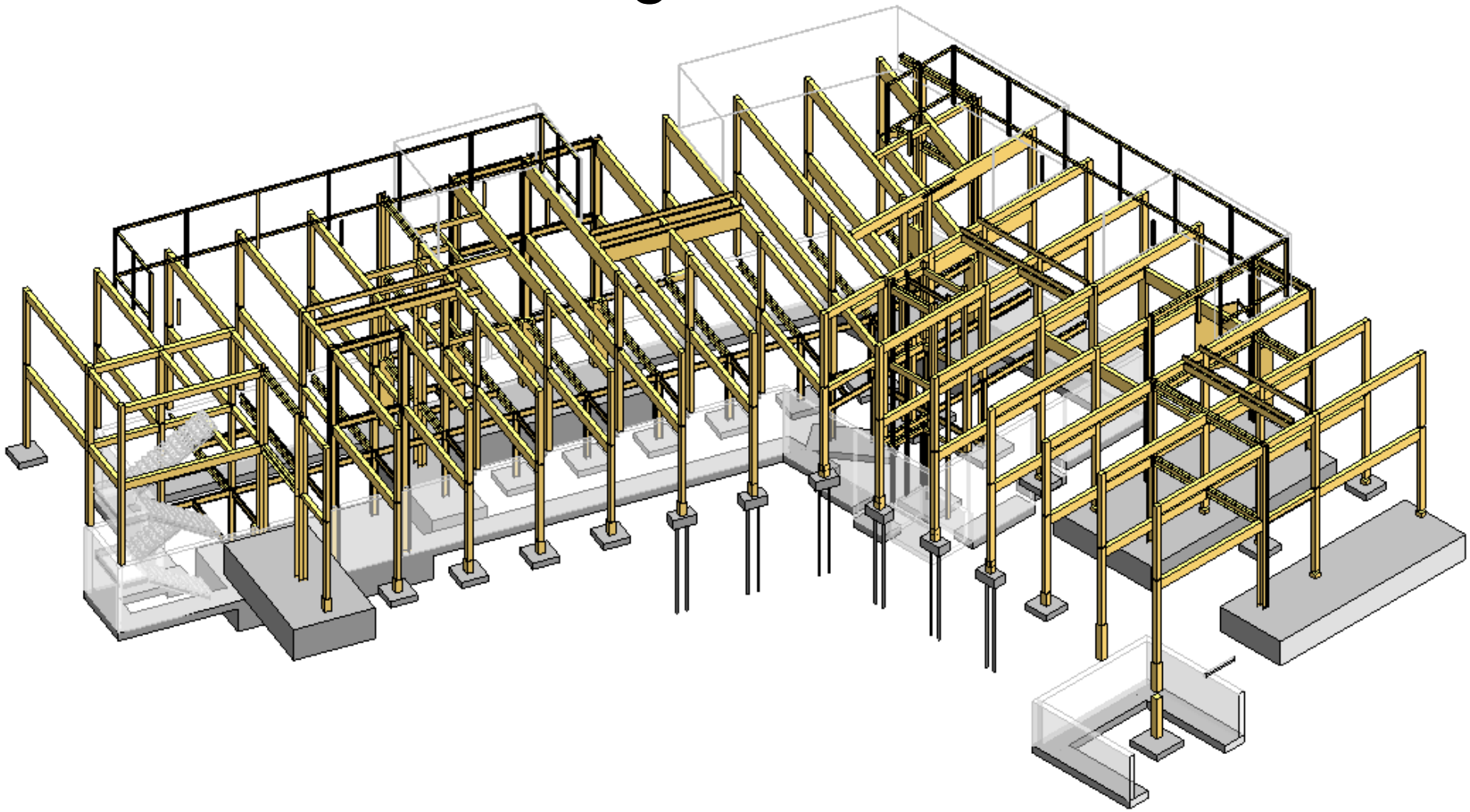
SICUT PATRIBUS SIT DEUS NOBIS
BOSTONIA
CONDITA AD
1630
CIVITATIS REGIMINE DONATA A.D. 1822

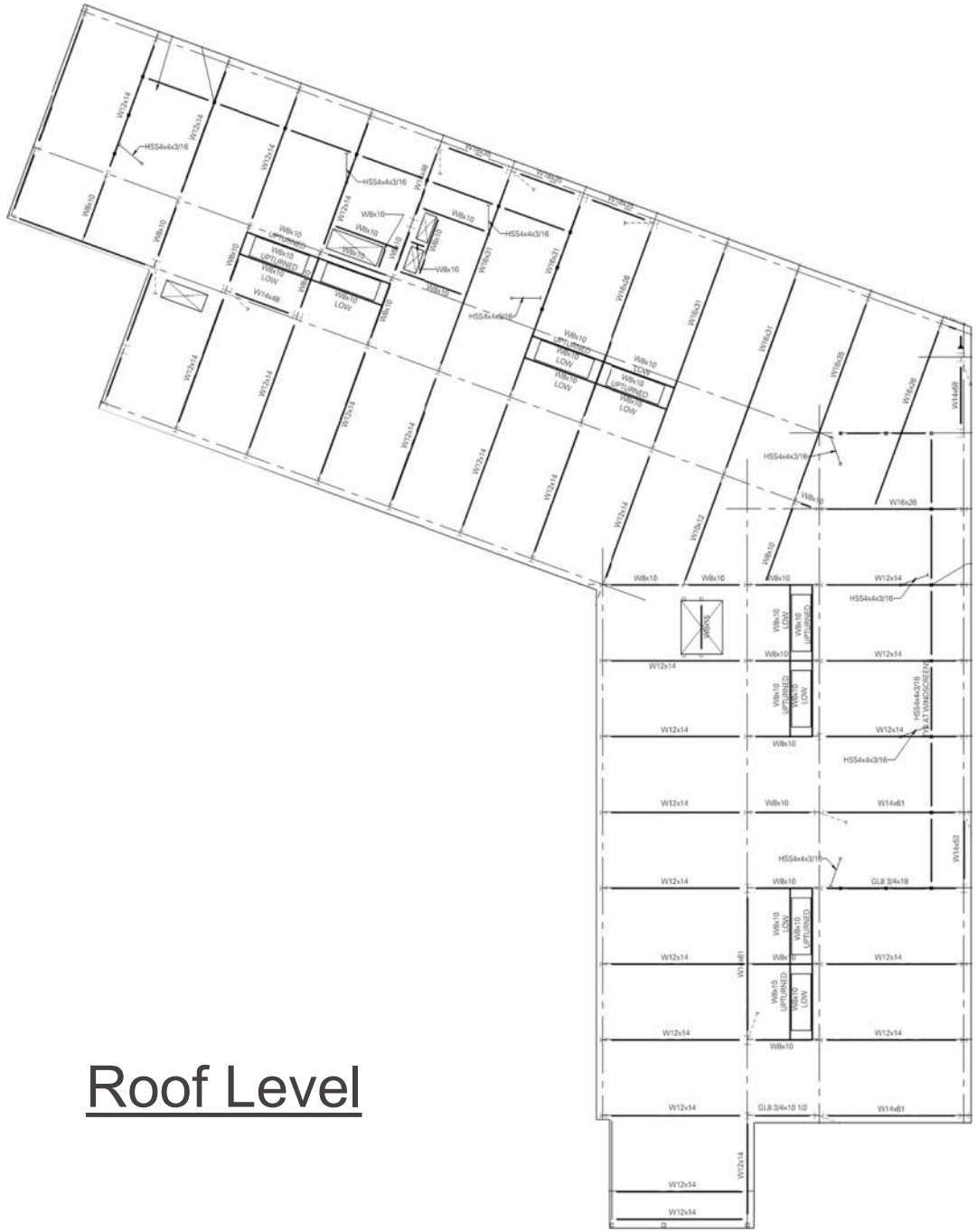
BUY CLEAN



BUY FAIR

Mass Timber vs. All-Steel Designs





Roof Level

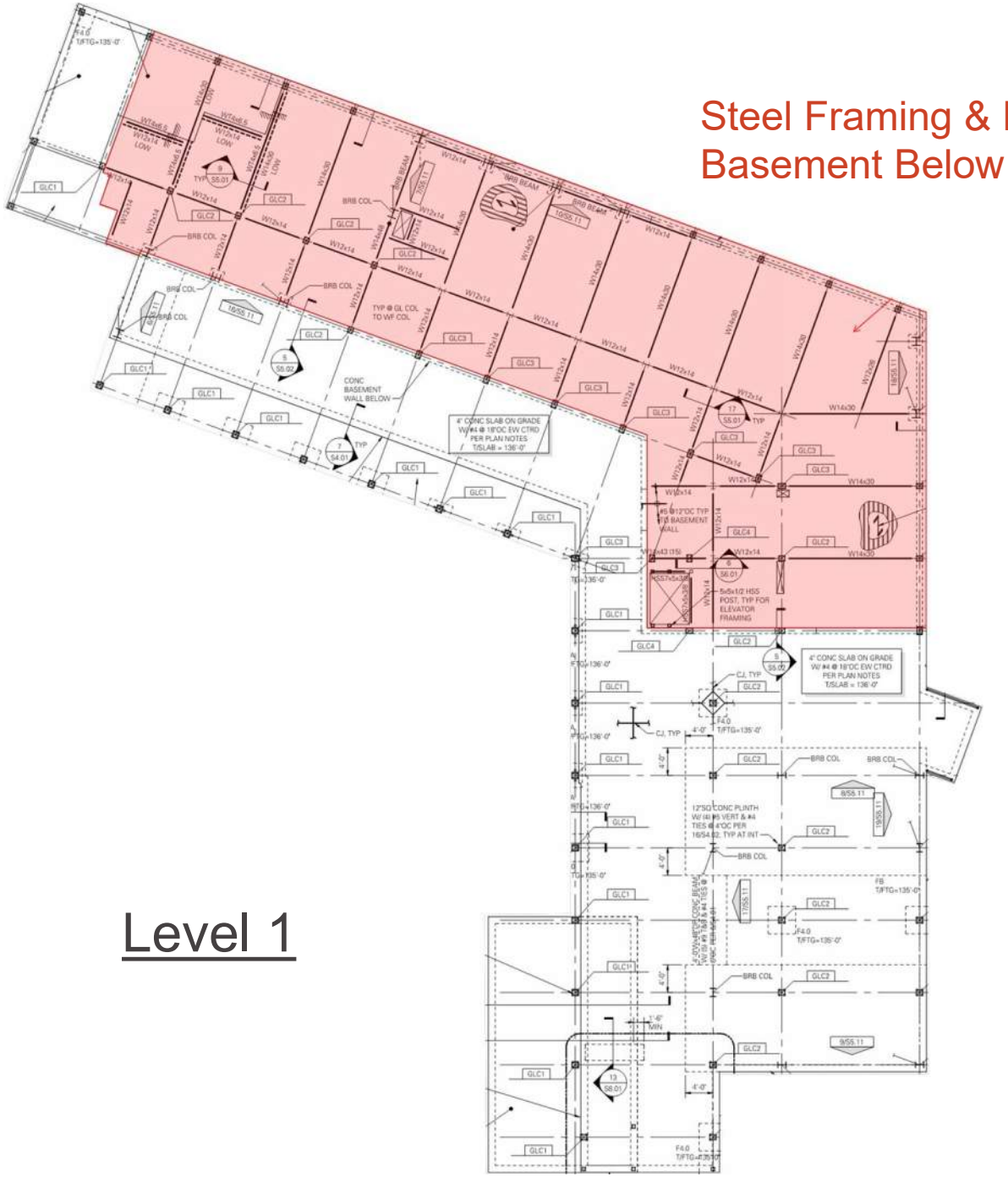
All-Steel Scenario

SUPERSTRUCTURE

- Wide Flange Steel Columns and Beams
- Composite Design Concrete Over Metal Deck
- BRBF Lateral System

SUBSTRUCTURE

- Shallow Concrete Foundations
- Concrete Basement Walls



Mass Timber Scenario

SUPERSTRUCTURE

- Glulam Columns and Beams
- 3-Ply CLT Deck with Concrete Topping
- BRBF Lateral System

SUBSTRUCTURE

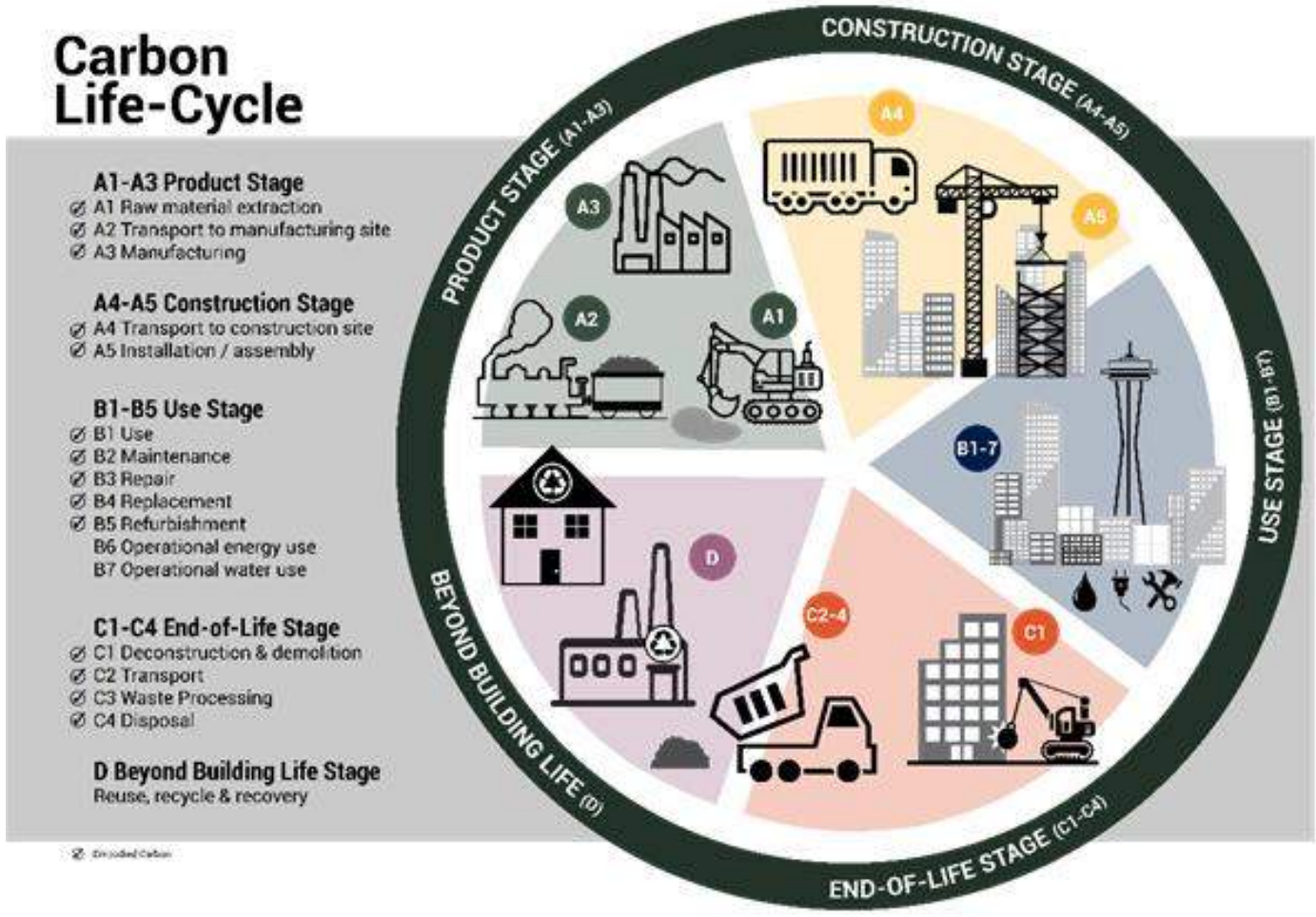
- Composite Steel at Red Portion Above Basement
- Shallow Concrete Foundations
- Concrete Basement Walls

LCA Methodology

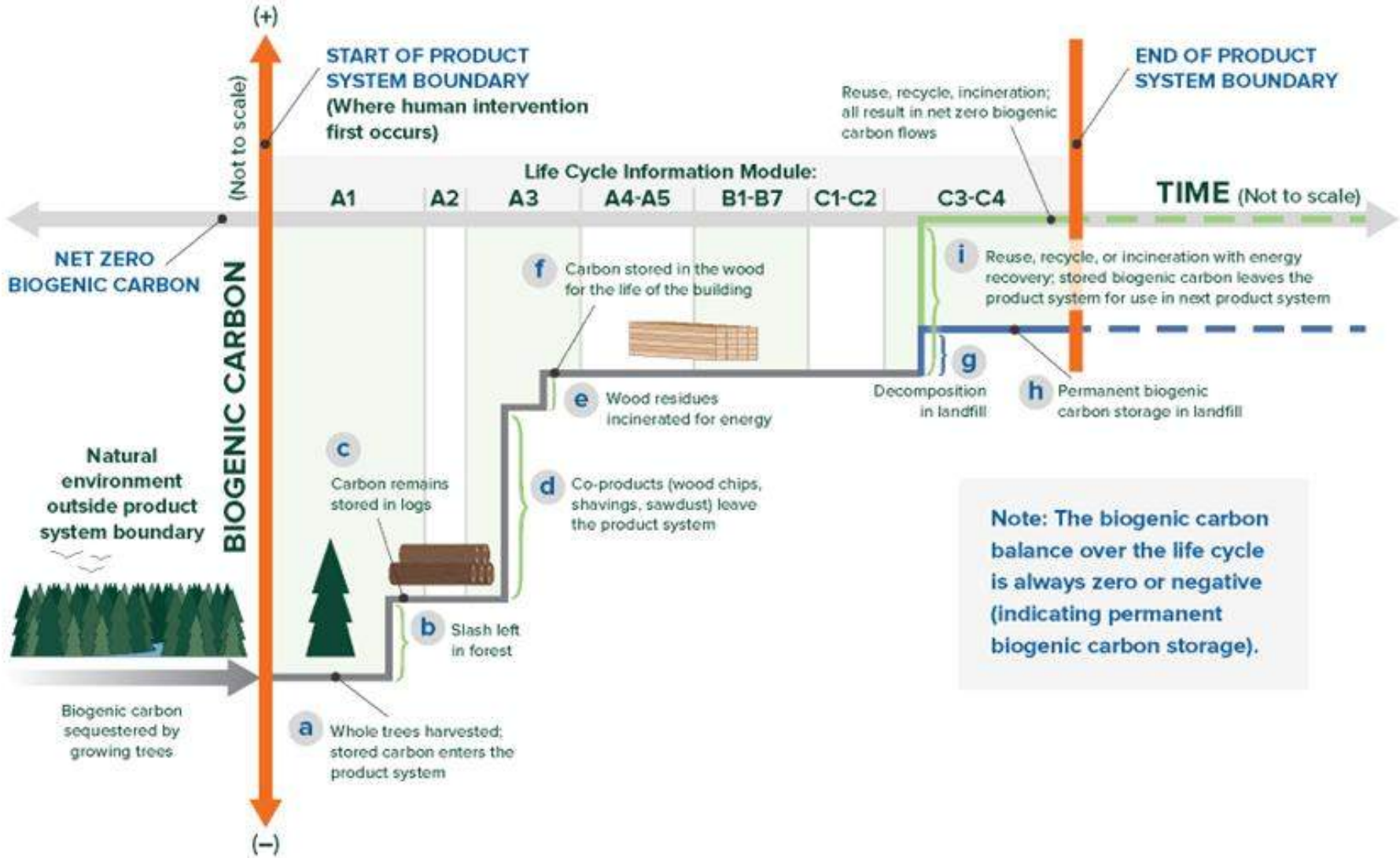
- Structure and Enclosure
- EPDs based off industry averages set by 2023 CLF North American Baseline Guide, except regional averages for softwood lumber and concrete
- 60-year building lifespan

One Click LCA software

Biogenic carbon reported separately and only considered as benefit during building lifespan



BIOGENIC CARBON FLOWS



Note: The biogenic carbon balance over the life cycle is always zero or negative (indicating permanent biogenic carbon storage).

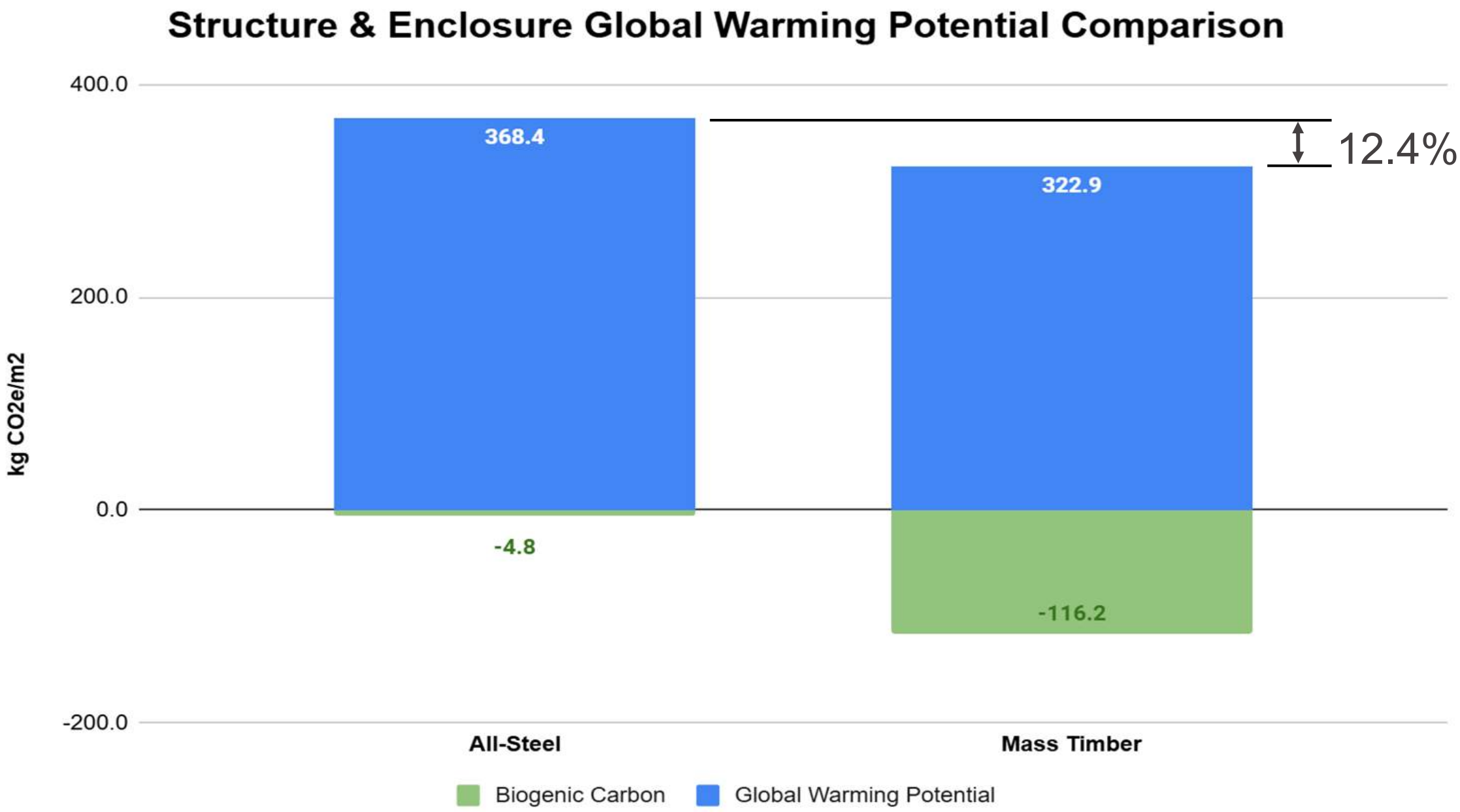
Source: WoodWorks

Procurement & End-of-life Decisions Affect Biogenic Carbon

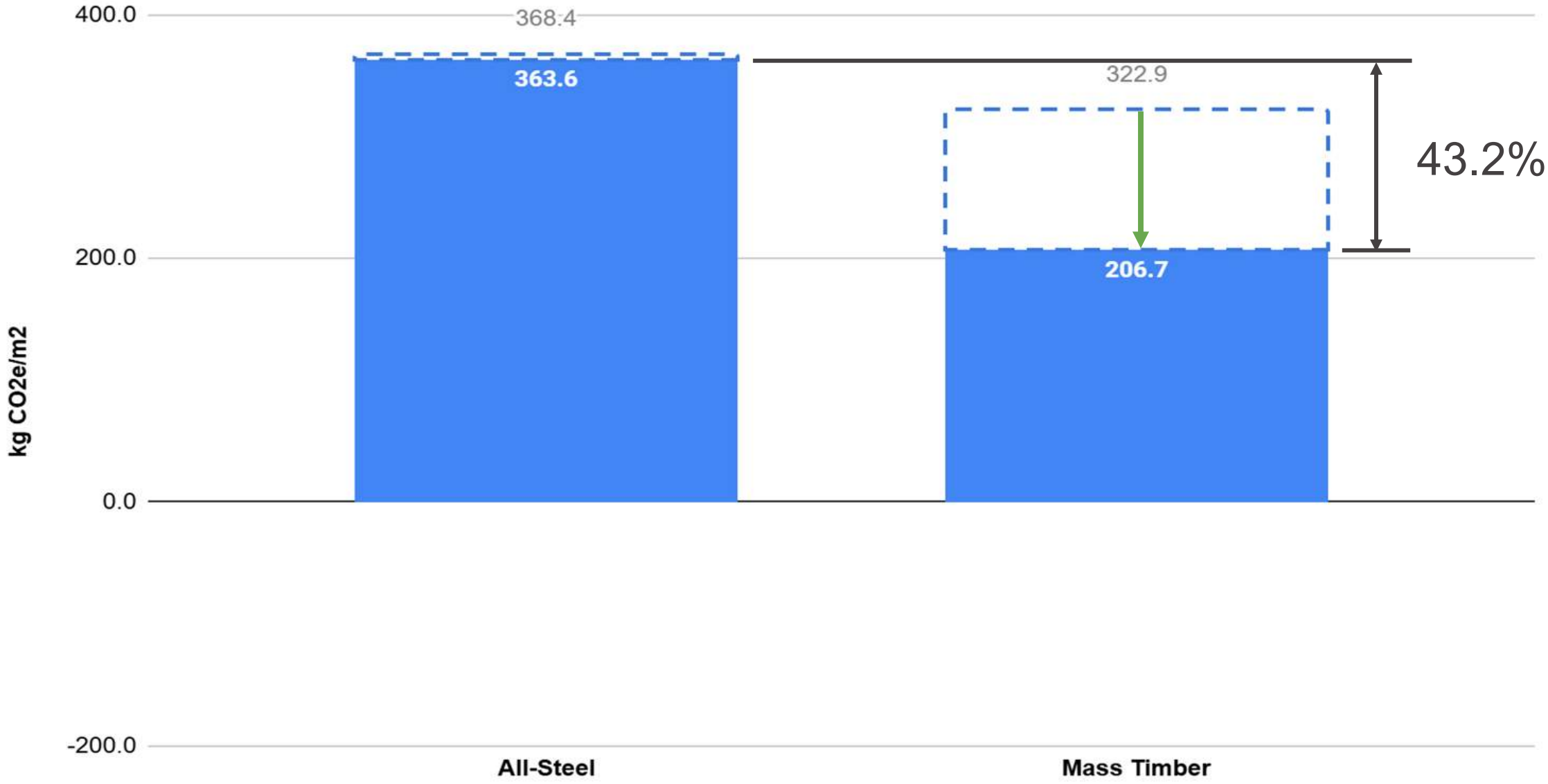
- Energy Grid
- Salvaged Wood
- Underutilized Wood Species
- Sustainable Sourcing

Well managed forests result in better soil quality, biodiversity, less risk of wildfire, and **greater carbon storage**

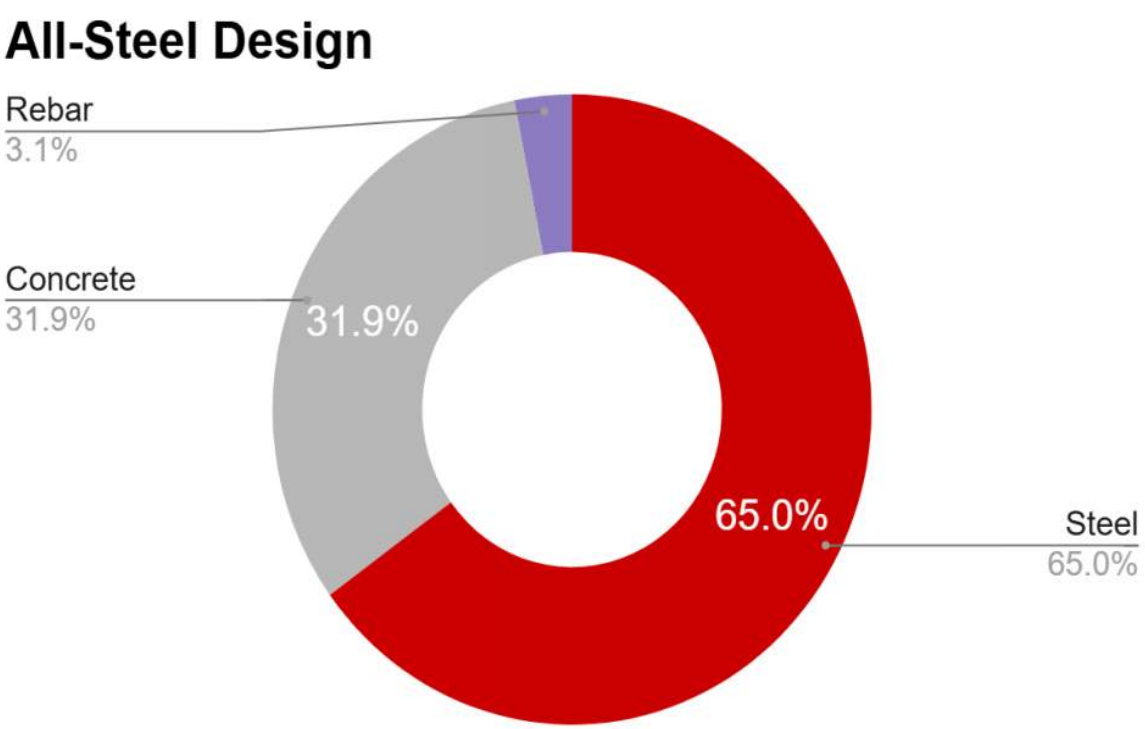
Comparative LCA Results

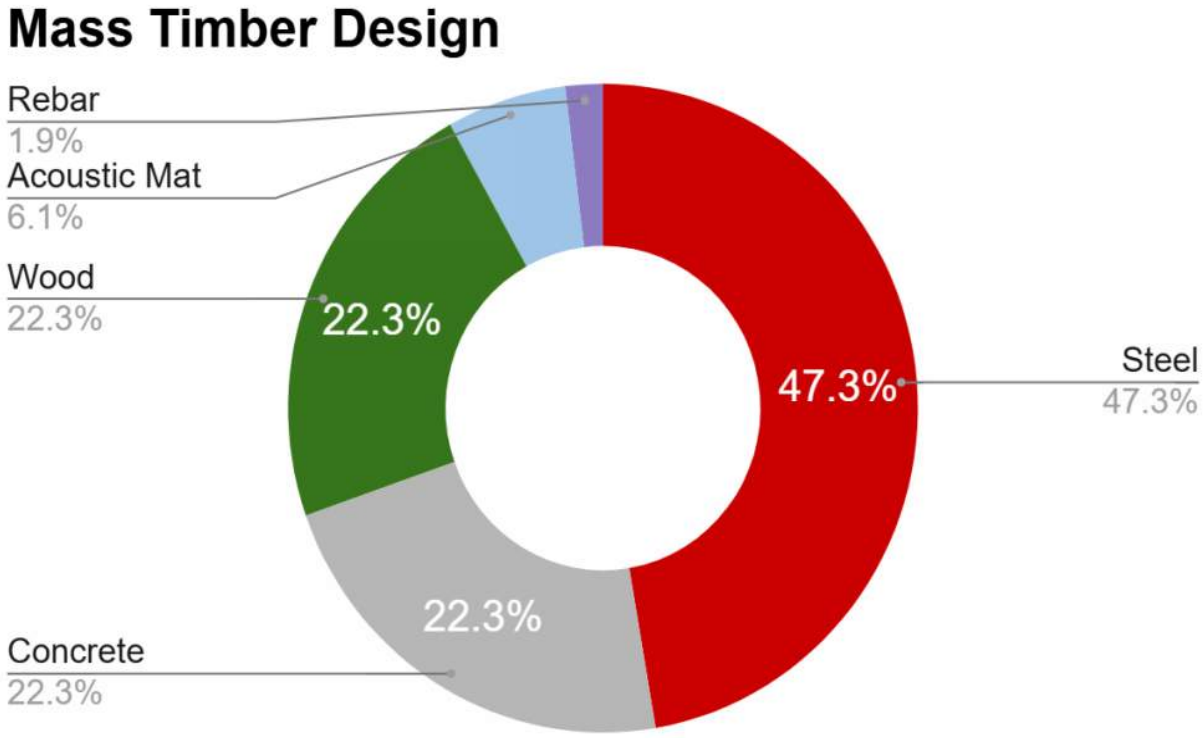

Structure & Enclosure Global Warming Potential Comparison
400.0
200.0
0.0
-200.0
kg CO2e/m2
368.4
-4.8
322.9
-116.2
12.4%
All-Steel
Mass Timber
Biogenic Carbon
Global Warming Potential

Structure & Enclosure Global Warming Potential Comparison

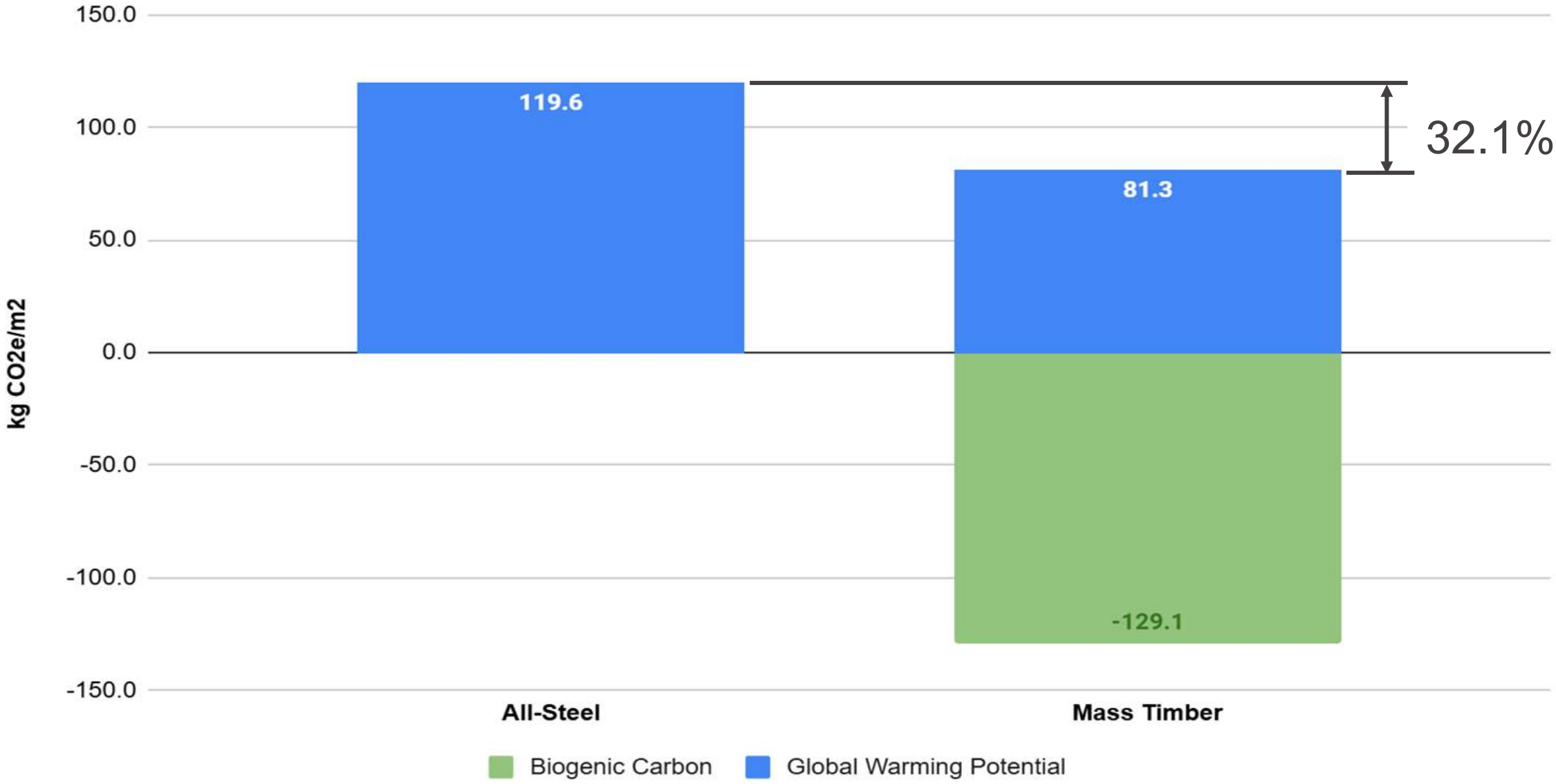


Structural System Material Impact Comparison

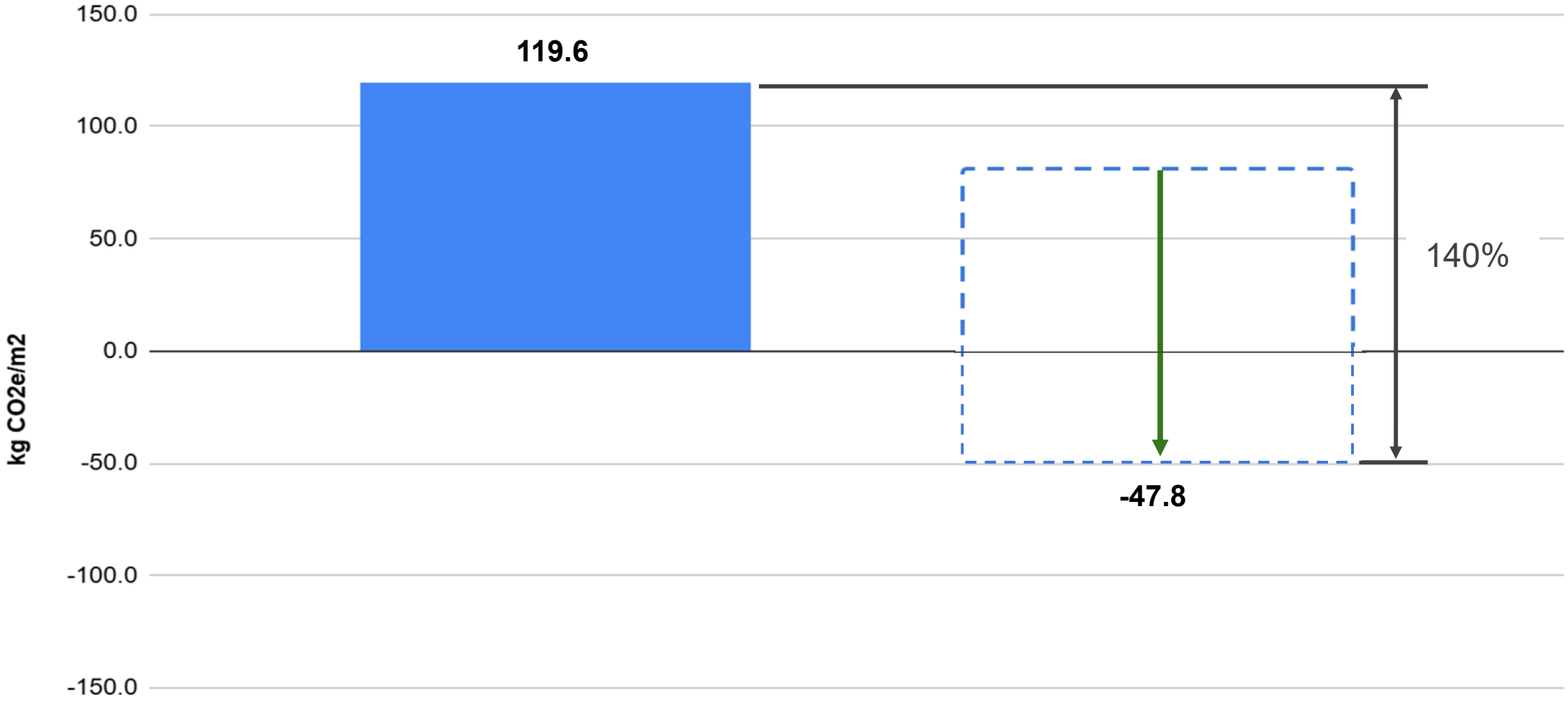




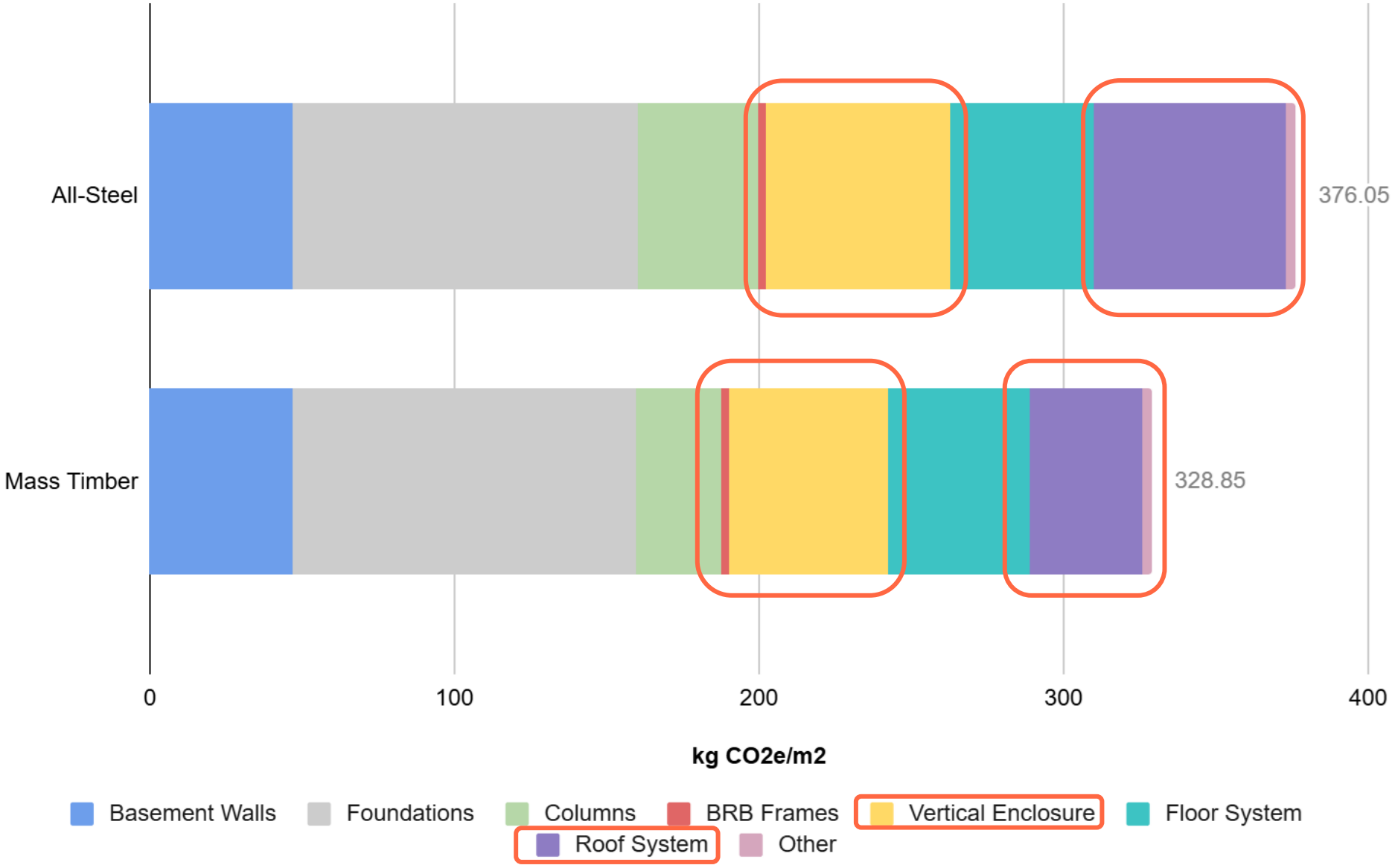
Structure Above Podium Global Warming Potential Comparison



Structure Above Podium Global Warming Potential Comparison



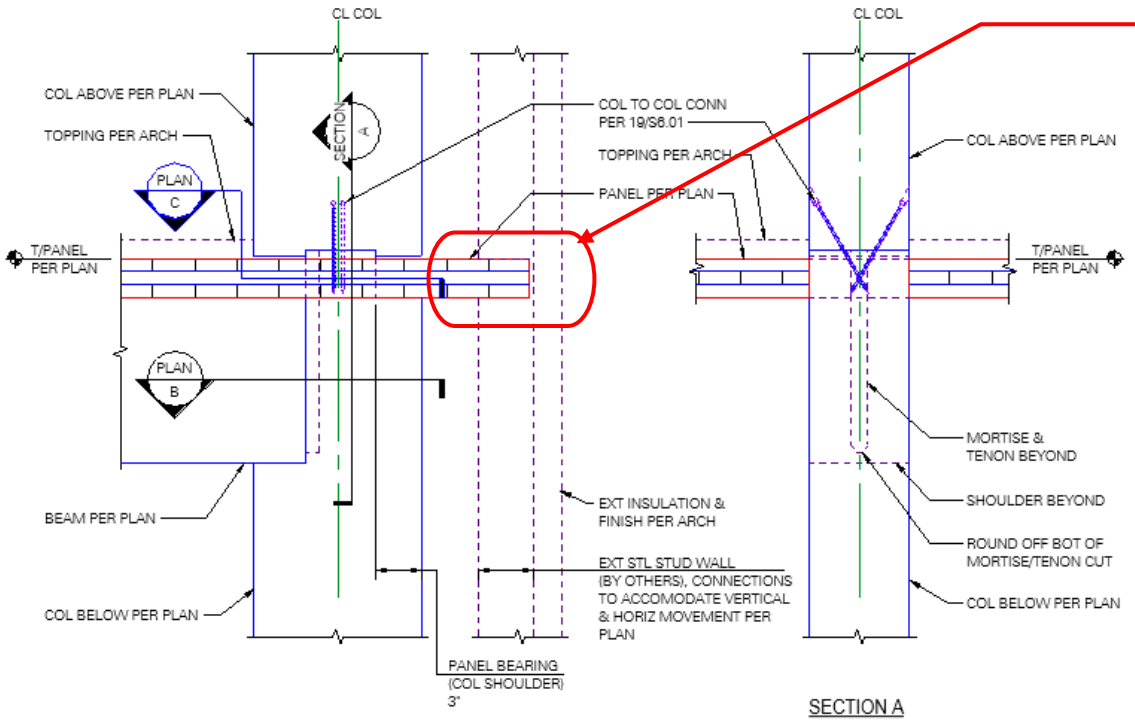
Structure & Enclosure Omniclass Global Warming Potential Comparison



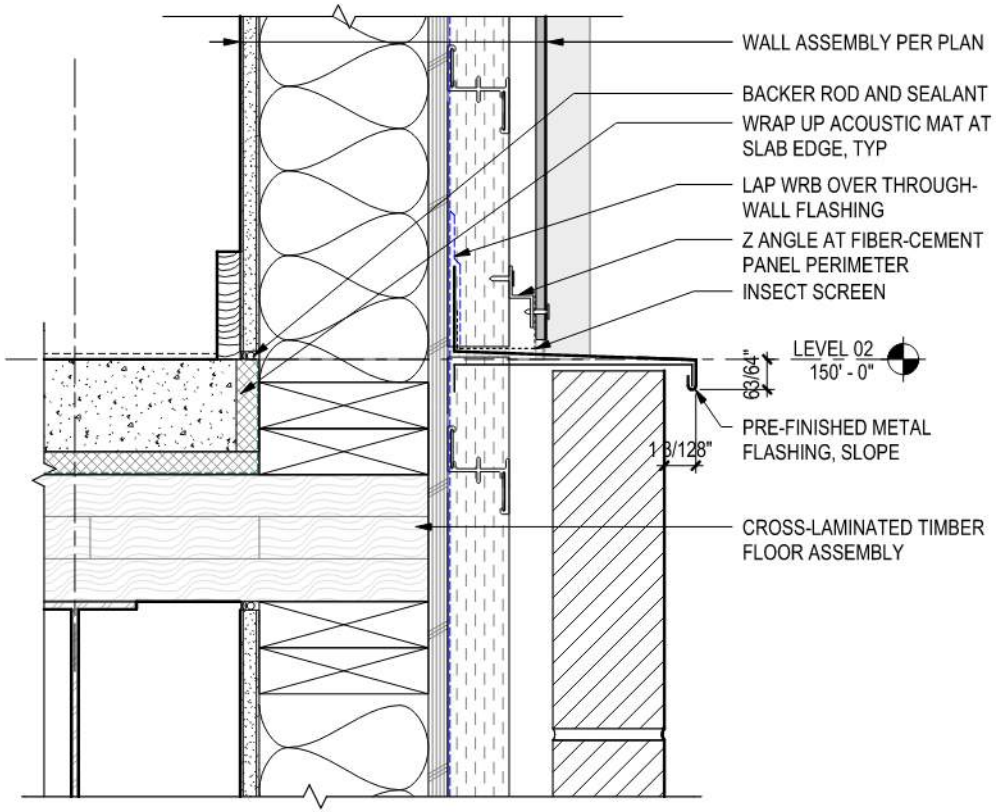
Vertical Enclosure Comparison

- Exterior walls are all non-load bearing
- Mass timber building has wood studs, Steel building has CFS studs
- All other materials are identical, except added continuous rigid insulation required for steel

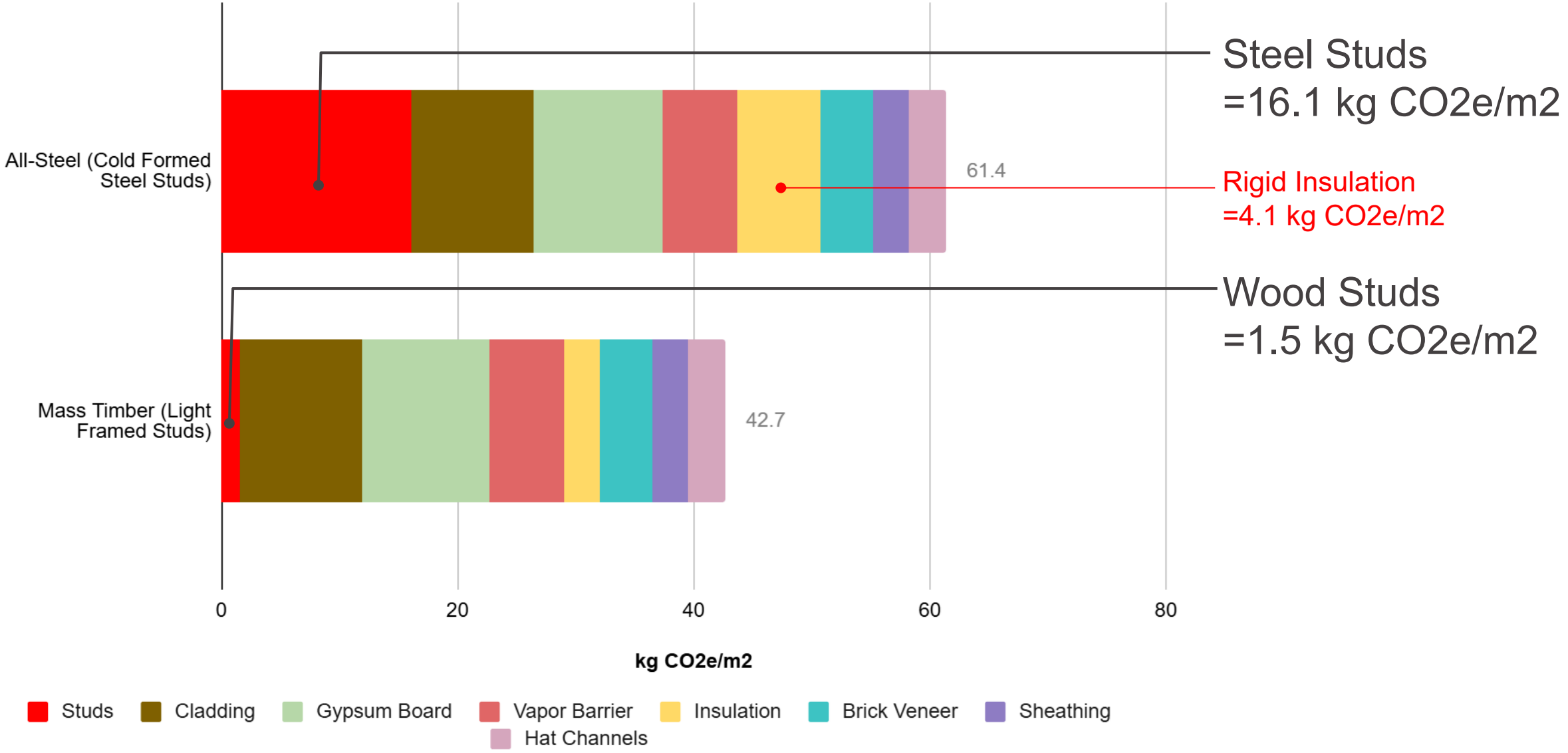
Wall connection at CLT allows for Vertical and Horizontal Movement



SECTION A



Exterior Wall Omniclass Global Warming Potential Comparison



Steel Studs
=16.1 kg CO2e/m2

Rigid Insulation
=4.1 kg CO2e/m2

Wood Studs
=1.5 kg CO2e/m2

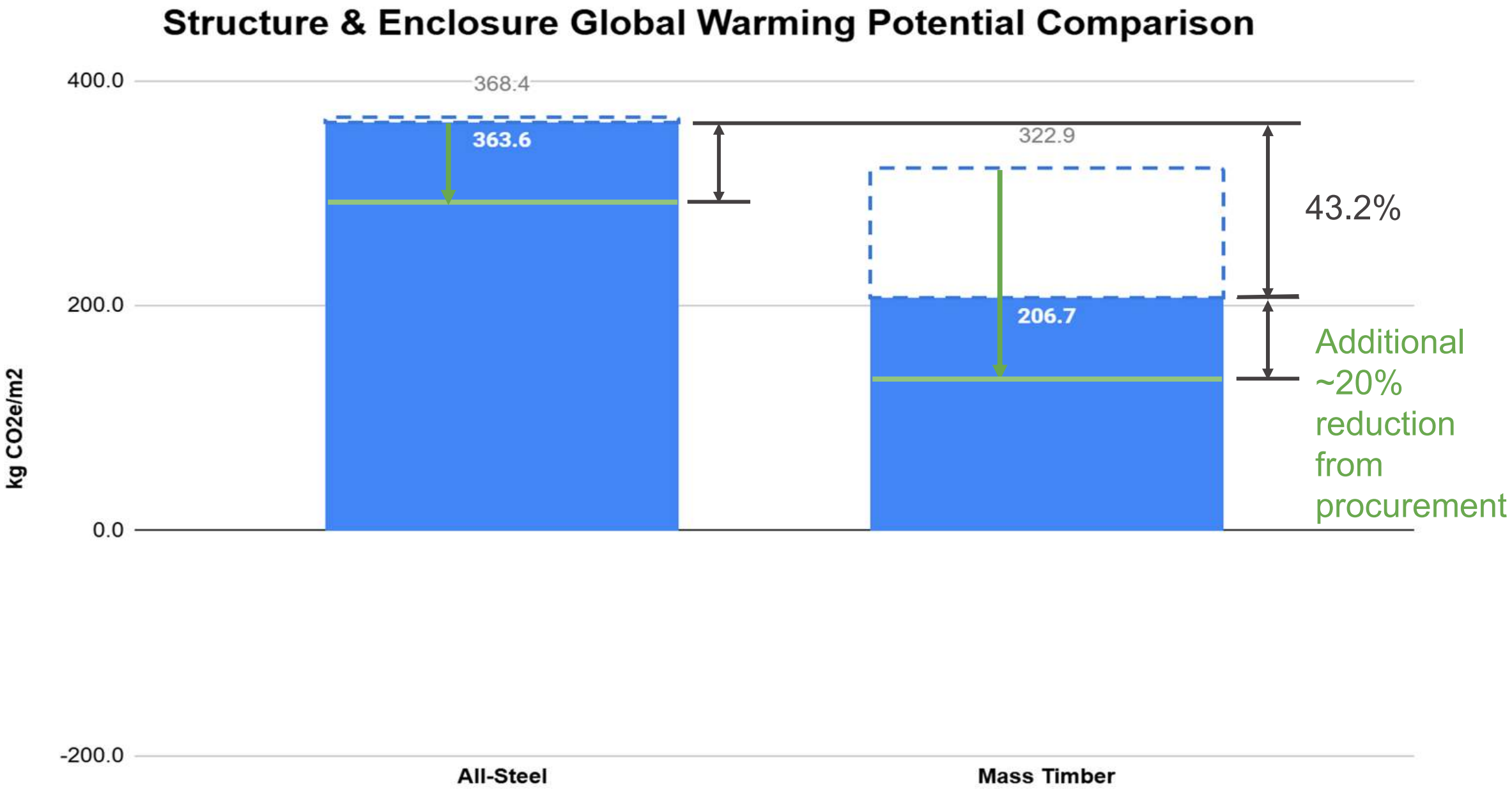
LCA Takeaways

Utilizing the mass timber design results in a **net-negative** superstructure.

By switching from cold-formed steel to light-framed wood studs **reduced the exterior wall impacts by 30%**.

The added concrete topping at the roof for the composite steel design had a large impact. This was not required for the mass timber design.

Further reduction opportunities to consider: Concrete and insulation procurement, dry floor assembly in lieu of concrete topping


Structure & Enclosure Global Warming Potential Comparison
400.0
200.0
0.0
-200.0
kg CO2e/m2
368.4
363.6
322.9
206.7
43.2%
Additional ~20% reduction from procurement
All-Steel
Mass Timber


Thank
You

QUESTIONS?

This concludes The American Institute of Architects Continuing Education Systems Course

Brendan Connolly, FAIA, Ryan Rideout, AIA, Arizona Dabrusin, PE

MITHŪN

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